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SPACE SYSTEMS

LORAL

Launch Integration & Operations Department

:03

DX6200-AWE-2002-016
August 30, 2002

02 OCT -4 PM 2:15

DEPT. OF TRANSPORTATION

To: Associate Administrator for Hazardous Materials Safety
Research and Special programs Administration
U.S. Department of Transportation
400 7th Street, SW
Washington, DC 20590-0001
Attention: Exemptions, DHM-31

From: Launch Integration & Operations Department
Space Systems/Loral
3825 Fabian Way; MS G84
Palo Alto, CA 94304-4604

Subject: Request for DOT Exemption for transporting spacecraft with empty pressurized on-board gas tank

107.105(a)(2) Applicant:

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Palo Alto, CA 94304-4604
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(650) 852-4046 (fax)
eft.alan@ssd.loral.com

107.105(a)(3) Not applicable; applicant is a U.S. resident/citizen.

107.105(a)(4) Manufacturing Exemption Locations

1. SPACE SYSTEMS/LORAL
3825 Fabian Way
Palo Alto, CA. 94303-4604

2. BOEING AEROSPACE
20403 68th Avenue SO
Kent, WA. 98032

3. BOEING AEROSPACE
2201 Seal Beach Blvd.
Seal Beach, CA. 90740

4. LOCKHEED MARTIN
   1111 Lockheed Way
   Sunnyvale, CA. 94089

5. JET PROPULSION LAB (JPL)
   California Institute of Technology
   4800 Oakgrove Drive
   Pasadena, CA. 91109

6. MOFFETT NAVAL AIR STATION
   So. Ellis Street Entrance
   Mountain View, CA. 94089

7. ASTROTECH SPACE OPERATIONS, L.P.
   1515 Chaffee Drive
   Titusville, FL. 32780

8. CAPE CANAVERAL AIR STATION
   Cape Canaveral, FL

9. SEA LAUNCH HOME PORT
   2700 Nimitz Road
   Long Beach, CA 90802

10. ARNOLD DEFENSE CENTER
    107 Avenue
    Arnold AirForce Base, TN. 37389-4000

11. OAKLAND AIRPORT
    Oakland International Airport
    1 Airport Drive
    Oakland, CA 94621

107.105(b) Confidential Treatment. Confidential treatment of the information contained in this document is requested.

Description of exemption proposal.

107.105(c)(1) Specific regulation of relief.

Space Systems/Loral requests a DOT Exemption to transport satellites (also called spacecraft) manufactured at the Palo Alto, California manufacturing facility. The standard spacecraft bus model, 1300 class, may include one of the two types of Xenon Pressurant Tank designs described in this document.

The spacecraft pressurant tanks are empty during transport, except for a relatively low storage/transportation pressure with either nitrogen, helium, xenon or argon. Since the pressurant tanks do not conform to DOT design specification for 3AL type cylinders as indicated in 49 CFR sections 173.301 and 178.46, the following information is provided for consideration.

Numerous test facilities and launch sites are available for specific use in the United States in which Space Systems/Loral's spacecraft may travel to depending upon the objective for travel. Tables 1 and 2 provide location information for spacecraft shipment. Table 1 identifies spacecraft test facility locations. Table 2 identifies spacecraft launch site locations. Table 3 is provided to summarize the three basic pressurant tank designs for the Space Systems/Loral standard 1300 class spacecraft.

The pressurant tanks are similar to those previously presented to DOT for Exemption DOT-E-12341, which is currently approved until April 30, 2004.

107.105(c)(2) Modes of Transportation.

The modes of transportation for the Space Systems/Loral satellites will be either by motor vehicle, cargo aircraft or a combination of both. The spacecraft pressurant tanks are internal to the spacecraft, which is packaged inside a spacecraft shipping container. The shipping container is used to protect, environmentally isolate, secure and transport the spacecraft. The shipping container also has provisions for towing. The spacecraft shipping container information is provided in Attachment (1) of this document.

TABLE 1 SPACECRAFT TEST FACILITIES

DESTINATION	DEPART FROM	MODE OF TRANS. Land	MODE OF TRANS. Air	ARRIVAL TO	TRAVEL TIME	DEPARTURE FROM	MODE OF TRANS. Land	MODE OF TRANS. Air	ARRIVAL TO	TRAVEL TIME
Kent, WA And return	SS/L Palo Alto, CA	X		Boeing Therm-Vac/ Acoustic Facility	16 Hrs	Boeing Therm-Vac/ Acoustic Facility	X		SS/L Palo Alto, CA	16 Hrs
Sunnyvale, CA And return	SS/L Palo Alto, CA	X		Lockheed Therm-Vac/ Acoustic Facility	8 Hrs	Lockheed Therm-Vac/ Acoustic Facility	X		SS/L Palo Alto, CA	8 Hrs
Anaheim, CA And return	SS/L Palo Alto, CA	X		Jet Propulsion Laboratory Solar Beam Facility	12 Hrs	Jet Propulsion Laboratory Solar Beam Facility	X		SS/L Palo Alto, CA	12 Hrs
Seal Beach, CA And return	SS/L Palo Alto, CA	X		Boeing Acoustic Test Facility	12 Hrs	Boeing Acoustic Test Facility	X		SS/L Palo Alto, CA	12 Hrs
Nashville, TN And return	SS/L Palo Alto, CA	X		Arnold Defense Center	20 Hrs	Arnold Defense Center	X		SS/L Palo Alto, CA	20 Hrs

TABLE 2 SPACECRAFT LAUNCH SITES

DESTINATION	DEPART FROM	MODE OF TRANS. Land	MODE OF TRANS. Air	ARRIVAL TO	TRAVEL TIME	DEPARTURE FROM	MODE OF TRANS. Land	MODE OF TRANS. Air	ARRIVAL TO	TRAVEL TIME
Cape Canaveral Air Station. Cape Canaveral, FL.	SS/L Palo Alto, CA	X		Moffett Naval Air Station, Sunnyvale, CA	5 Hrs	Moffett Naval Air Station, Sunnyvale, CA		X	Cape Canaveral Air Station. Cape Canaveral, FL.	8 Hrs
	Cape Canaveral Air Station. Cape Canaveral, FL.	X		Astrotech Facility, Titusville, FL	5 Hrs	Astrotech Facility, Titusville, FL	X		Cape Canaveral Air Station. Cape Canaveral, FL.	5 Hrs
Cape Canaveral Air Station. Cape Canaveral, FL.	SS/L Palo Alto, CA	X		Astrotech Facility, Titusville, FL	40 Hrs	Astrotech Facility, Titusville, FL	X		Cape Canaveral Air Station. Cape Canaveral, FL.	5 Hrs
Long Beach, CA SeaLaunch Home Port	SS/L Palo Alto, CA	X		Moffett Naval Air Station, Sunnyvale, CA	5 Hrs	Moffett Naval Air Station, Sunnyvale, CA		X	LAX Airport Los Angeles	2 Hrs
	LAX Airport Los Angeles	X		Long Beach, CA SeaLaunch Home Port	2 Hrs					
Long Beach, CA SeaLaunch Home Port	SS/L Palo Alto, CA	X		Moffett Naval Air Station, Sunnyvale, CA	5 Hrs	Moffett Naval Air Station, Sunnyvale, CA		X	John Wayne Orange County Airport	2 Hrs
	John Wayne Orange County Airport	X		Long Beach, CA SeaLaunch Home Port	2 Hrs					
Long Beach, CA SeaLaunch Home Port	SS/L Palo Alto, CA	X		Moffett Naval Air Station, Sunnyvale, CA	5 Hrs	Moffett Naval Air Station, Sunnyvale, CA		X	Long Beach Airport	2 Hrs
	Long Beach Airport	X		Long Beach, CA SeaLaunch Home Port	2 Hrs					
Long Beach, CA SeaLaunch Home Port	SS/L Palo Alto, CA	X		Long Beach, CA SeaLaunch Home Port	10 Hrs					
Overseas Launch Site	SS/L Palo Alto, CA	X		Oakland Airport, Oakland, CA	6 Hrs	Oakland Airport, Oakland, CA		X	Various	Various
Overseas Launch Site	SS/L Palo Alto, CA	X		Moffett Naval Air Station, Sunnyvale, CA	5 Hrs	Moffett Naval Air Station, Sunnyvale, CA		X	Various	Various

107.105(c)(3) Description of proposed exemption

-- Written description

The standard SS/L 1300 class spacecraft bus propulsion configuration has been presented as part of the DOT-E-12341 Exemption application. The tanks that this request is addressing are additional pressurant tanks that will eventually hold either Helium or Xenon under pressure. However, during transportation, these tanks will normally be pressurized with Helium, but could possibly be pressurized with Nitrogen, Xenon or Argon as alternatives. They are identified as either "Helium" or "Xenon" tanks because that is their ultimate intended use, even if that isn't the gas that may be pressurizing it during transportation.

The three tanks that this request covers, are listed in Table 3. Two of the tanks are designated to contain Xenon gas, and a third tank is designated to contain Helium gas.

TABLE 3 PRESSURANT TANK INFORMATION

	Pressurant Tank (Helium - 65 liter)	Pressurant Tank (Xenon - 65 liter)	Pressurant Tank (Helium - 82 liter)
SS/L Part Number	E137830-01	E137830-02	E137830-04
Vendor Part Number	Lincoln Composites 220145-1	Lincoln Composites 220142-1	Lincoln Composites 220165-01
SS/L Performance Spec	E125301	E172856	E245929
Dimensions	13" x 39"	13" x 39"	13" x 46"
Design Burst Pressure	6,000 psi	4,000 psi	1.5:1 (4050 psi)
Design Proof Pressure	5,200 psi	3,375 psi	1.25:1 (3375psi)
Maximum Expected Operating Pressure (MEOP)	4,000 psi	2,700 psi	2,700 psi
Actual Burst Pressure	6,500 psig (leakage)	5,500 psig (rupture)	Available about October 2002
Lincoln Composites - Qualification Test Report number	19410-53000-1	19410-53000-2	Available about October 2002
Transportation Pressure	275 psi	275 psi	275 psi
Transportation Safety Factor	>21	>14	Available about October 2002
Tank Volume	4,000 in^3	4,000 in^3	5,002 in^3

A brief description of each of the three tanks is provided.

Pressurant Tank (Helium - 65 liter).

The tank is a 13.0-inch-diameter by 39-inch-long cylinder with a volume of 4,000 in^3 (65.6 liters) at its MEOP of 4,000 psia at 60 ° C, per SS/L Performance Specification E125301. Refer to Table 5 for actual quantities. Refer to Figure 1 for a sketch of the tank.

Pressurant Tank (Xenon - 65 liter).

The tank is a 13.0-inch-diameter by 39-inch-long cylinder with a volume of 4,000 in^3 (65.6 liters) at its MEOP of 2,700 psia at 60 °C, per SS/L Performance Specification E172856. Refer to Table 5 for actual quantities. Refer to Figure 1 for a sketch of the tank. The xenon tank uses liners identical to the helium tank, but the wrap thickness is reduced due to the lower operating and burst pressures, thus reducing the tank mass.

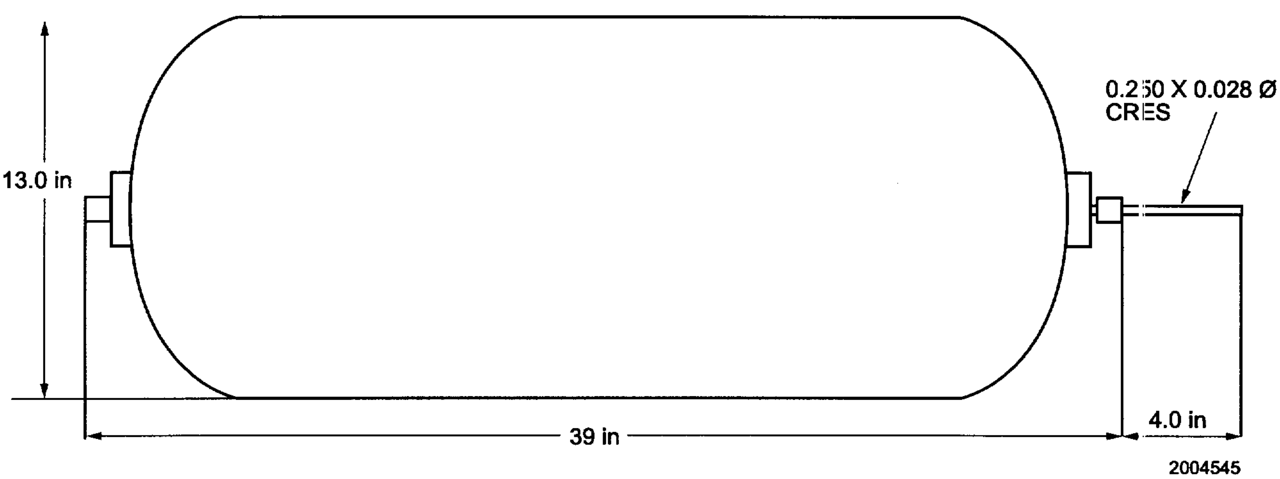


Figure 1 65 Liter Pressurant Tank

Pressurant Tank (Xenon - 82 liter).

The tank is a 13.0-inch-diameter by 46-inch-long cylinder with a volume of 5,002 in^3 (82 liters) at its MEOP of 2,700 psia at 60 °C, per SS/L Performance Specification E245929. Refer to Table 5 for actual quantities. Refer to Figure 2 for a picture of the tank.

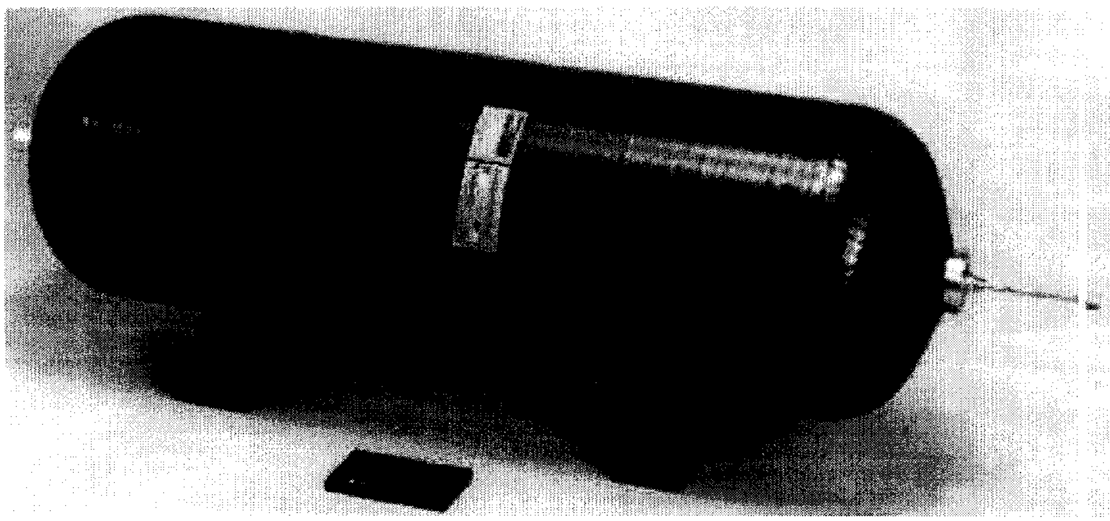


Figure 2 82 Liter Pressurant Tank

Each tank's construction consists of a full overwrap of T1000 graphite-epoxy composite over a seamless T6061 aluminum alloy liner. Reinforced metal bosses on each end of the tank are used for mounting. A friction-welded bimetallic tube that transitions from aluminum to stainless steel is included at the port end. The bottom end of each tank is supported by an aluminum bracket that attaches to elevated panels. Axial tank loads are reacted by struts to the ACS ring. Two graphite-epoxy struts react lateral loads at the top end of tank.

Refer to Figure 3 for a view of the Primary Satellite Structure of the satellite. Refer to Figure 4 for a view of the Secondary Satellite Structure. Each tank is bolted to the central cylinder as shown in Figure 5.

The tanks comply with MIL-STD-1522A, Leak Before Burst (LBB) design. The Qualification Test Reports are also provided as Attachments (3) and (4) for the 65 liter tanks. The qualification test report for the 82 liter tank will be provided when received, which is expected in October 2002.

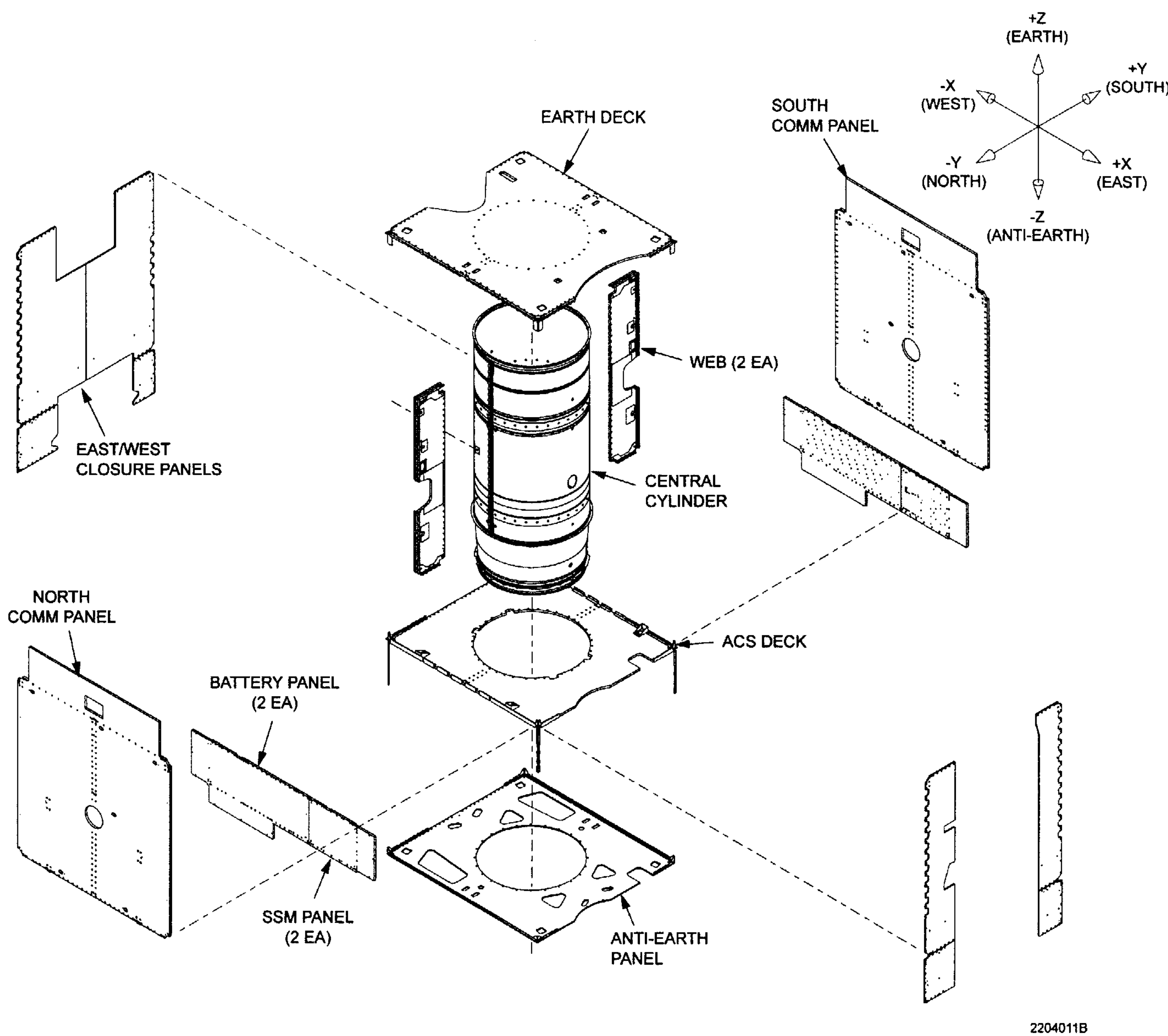


Figure 3 Primary Structure - Expanded View

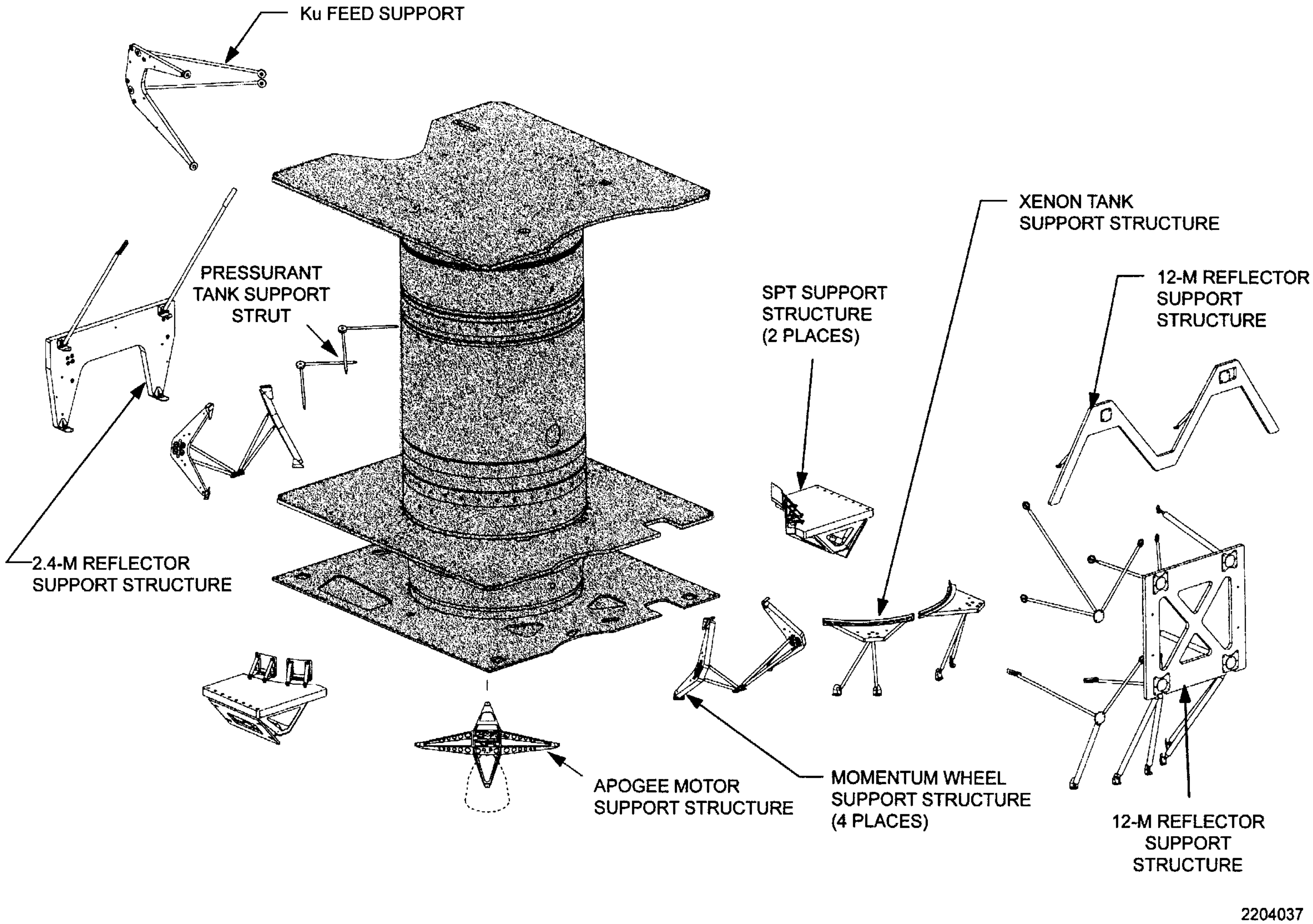


Figure 4 Secondary Structure - Expanded View

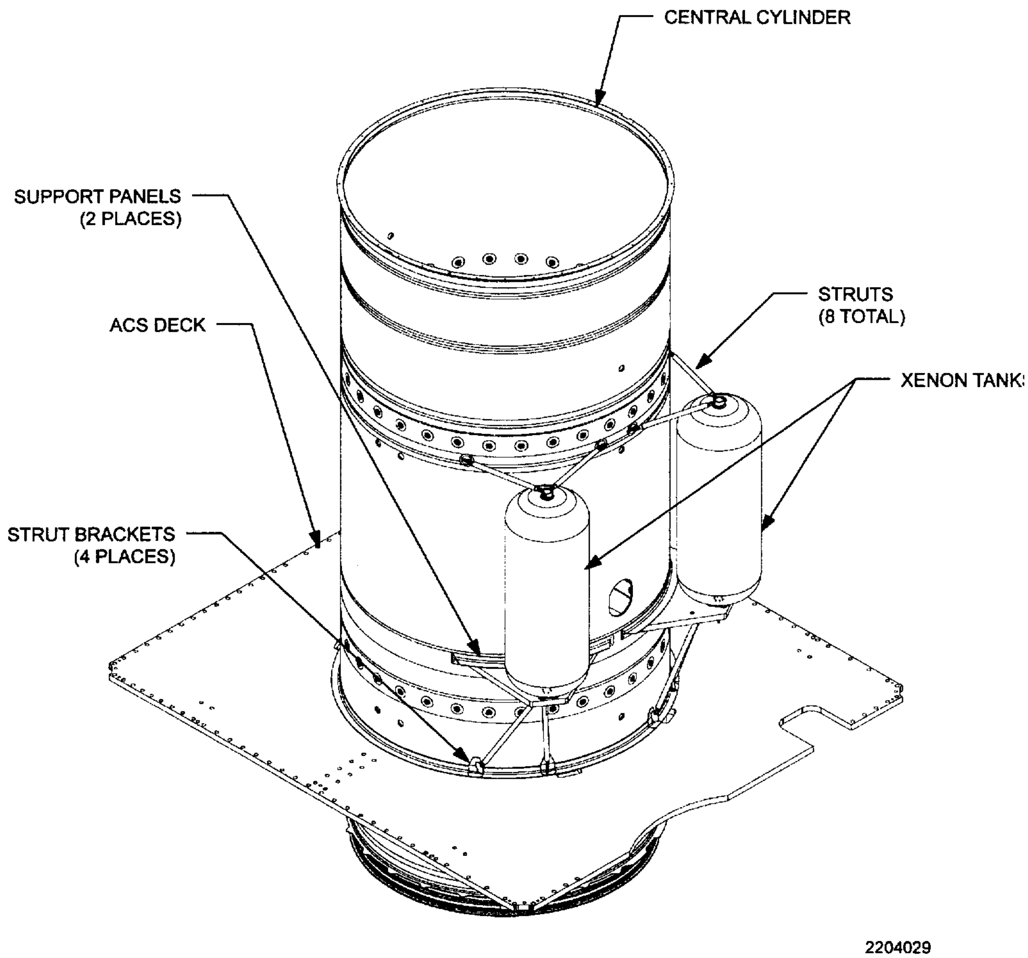


Figure 5 Xenon Tank Location

107.105(c)(4) Proposed duration or schedule of events for which the exemption is sought.
SS/L is requesting a full term limit (24 months) on the duration of this exemption with renewal options. The objective is to cover all SS/L spacecraft configurations and domestic shipments within the full term limit. This would alleviate the need to apply for multiple DOT Exemptions for each spacecraft manufactured at the Palo Alto facility (approximately 8-10 per year). This request does not include a schedule of events because no schedule exists at this time, however, Tables 1 and 2 provide all modes of spacecraft travel for which this exemption is sought for the next 24 months. If any changes to the existing modes of shipment or transportation occur within the term limit, a modification to the exemption will be forwarded for review and consideration.

107.105(c)(5) Statement outlining basis for seeking relief from compliance with the specified regulations.
SS/L spacecraft pressurant tank designs are not designed with the intent as specified in 49 CFR section 178.46. The tanks are designed, for high strength and low weight, as spacecraft flight hardware and will not be subjected to flight conditions, other than in a test environment, before they are actually launched into space. It is in SS/L's best interest to seek relief from compliance to the aforementioned requirement without an end resolution to compliance. This request for exemption is not in scope with a nominal request as mentioned in section 107.105(c)(1) of this document. The transportation pressures mentioned here are shipping/storage pressures only and are only a fraction of the actual design pressures for the tanks. The gases used during shipment are inert and in such relatively small quantities that they would have no public or environmental impact.

107.105(c)(6) Emergency processing in accordance with 107.117.
Not Applicable. Emergency Processing is not necessary?

107.105(c)(7) Identification and description of the hazardous materials planned for transportation under the exemption.

Table 4 provides a description of the four inert gases that could be used for to provide tank pressurization during transportation. However, Helium is the gas of preference.

TABLE 4 HAZARDOUS MATERIALS DESCRIPTION

Name	Nitrogen Gas (N_2)	Helium Gas (He)	Argon Gas (Ar)	Xenon Gas (Xe)
Composition iaw	Gaseous Nitrogen MIL-P-27401, Type 1, Grade B	Gaseous Helium MIL-P-27407, Type 1, Grade A	Gaseous Argon, MIL-PRF-27415	Gaseous Xenon, SS/L statement of work
ERG/ID Numbers	121 / 1066	121 / 1046	121 / 1006	121 / 2036
Molecular Weight	28.01348	4.002602	39.948	131.29
DOT Class	Non-flammable, Non-liquefied compressed gas (Hazard Class 2, Division 2.2)			
Quantity	See Table 5, below			
Form	Gaseous			
Properties	Odorless, Colorless, Non-flammable inert gas			

Table 5 provides the quantities of the four inert gases that could be present for each pressurant tank design, at a shipping pressure of 275 psi.

TABLE 5 HAZARDOUS MATERIALS QUANTITY

		Helium Tank (65 liter) @ 275 psi	Xenon Tank (65 liter) @ 275 psi	Xenon Tank (82 liter) @ 275 psi
Nitrogen Gas	gm	1413.2	1413.2	1782.9
	oz	49.8	49.8	62.9
	lbm	3.1	3.1	3.9
Helium Gas	gm	201.9	201.9	254.7
	oz	7.1	7.1	8.9
	lbm	0.4	0.4	0.6
Argon Gas	gm	2015.3	2015.3	2542.4
	oz	71.1	71.1	89.7
	lbm	4.4	4.4	5.6
Xenon Gas	gm	6623.4	6623.4	8355.6
	oz	233.6	233.6	294.7
	lbm	14.6	14.6	18.4

107.105(c)(8) Description of packaging, including specification or exemption number as applicable, to be used in conjunction with the requested exemption

As shown in Figures 3, 4 & 5, the tanks are mounted internally to the SS/L spacecraft. There are panels that enclose the spacecraft and give it a "box" like appearance.

All of SS/L's spacecraft are shipped/transported in an SS/L shipping container. See Attachment (1). Five spacecraft containers currently exist, and are virtually identical. The shipping container has special provisions for maintaining a secure and contaminant free environment for the spacecraft and contents during shipping. The spacecraft is positioned in the shipping container as depicted in Attachment (1), the top lid is then attached and the spacecraft is secured in place. Attachment (1) to this request provides additional information regarding the SS/L spacecraft shipping container. The environment that the spacecraft will be exposed to inside this shipping container is below the levels that it will experience during launch operations. Installed accelerometers are monitored to ensure the shipping levels are below these spacecraft qualified launch requirements.

The spacecraft shipping container will display labeling and marking necessary to be in compliance with 49 CFR 172.300 and 172.400, as appropriate. The DOT Exemption will also be displayed on the spacecraft shipping container, as appropriate.

107.105(c)(9) Alternative packagings include quality assurance controls, package design, manufacture, performance test criteria, in-service performance and service-life limitations.

Not applicable. There are no alternate modes of packaging and shipping for the SS/L spacraft.

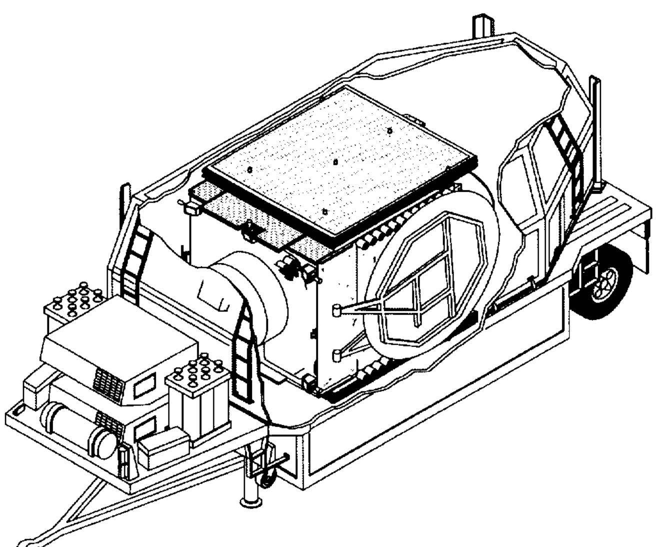
ACRONYMS AND ABBREVIATIONS

ACS	Attitude Control Subsystem
Ar	Argon
CFR	Code of Federal Regulations
DOT	Department of Transportation
ERG	Emergency Response Guidebook
He	Helium
iaw	in accordance with
in^3	Cubic Inch
JPL	Jet Propulsion Laboratory
LBB	Leak Before Burst
MEOP	Maximum Expected Operating Pressure
N_2	Nitrogen
psi	Pounds per square inch
psia	Pounds per square inch - absolute
psig	Pounds per square inch - gauge
SPT	Stationary Plasma Thruster
SS/L	Space Systems/Loral
SSM	Subsystem Support Module
UN	United Nations
Xe	Xenon

FIGURES

ATTACHMENTS

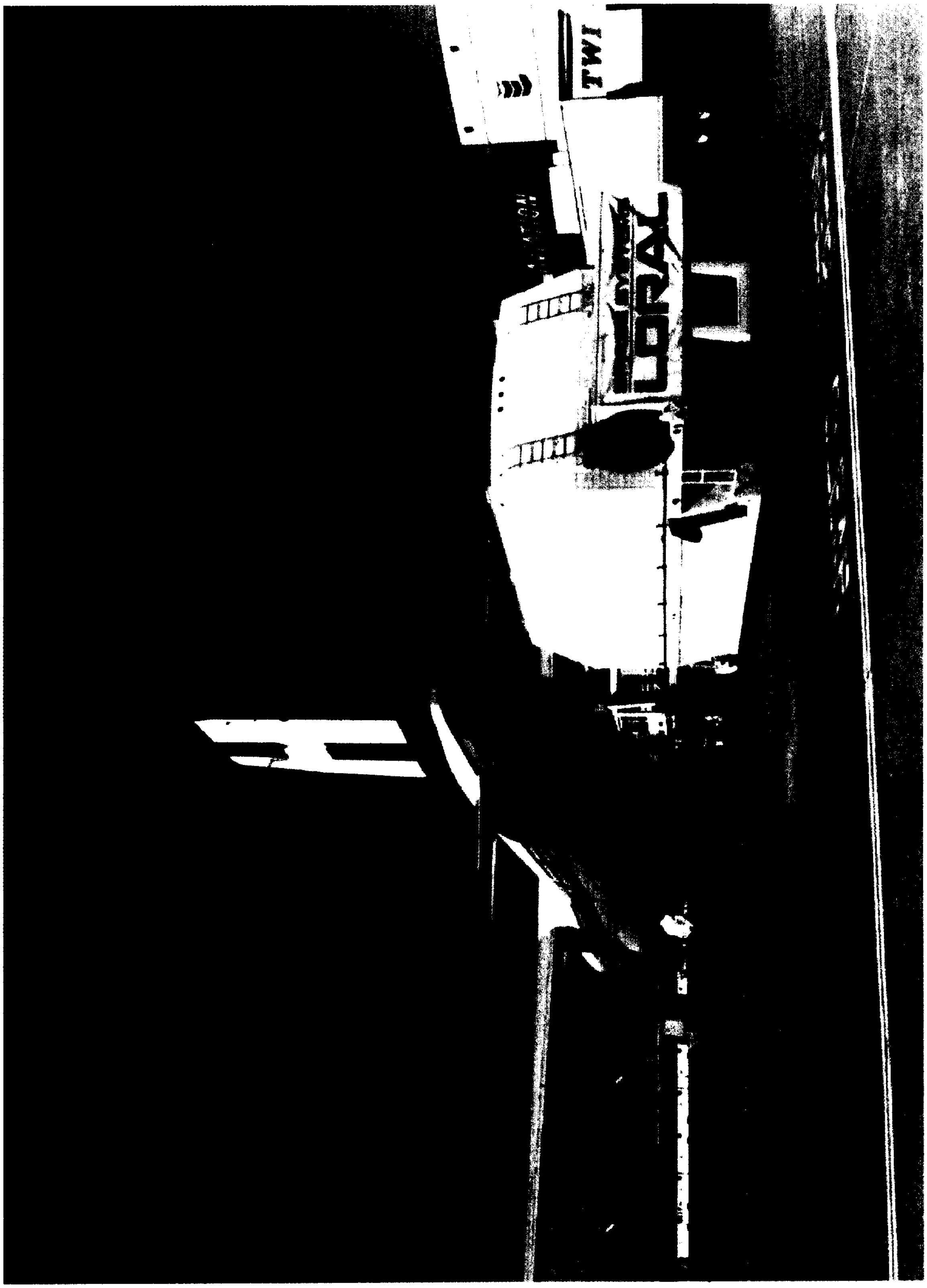
SPACECRAFT SHIPPING CONTAINER



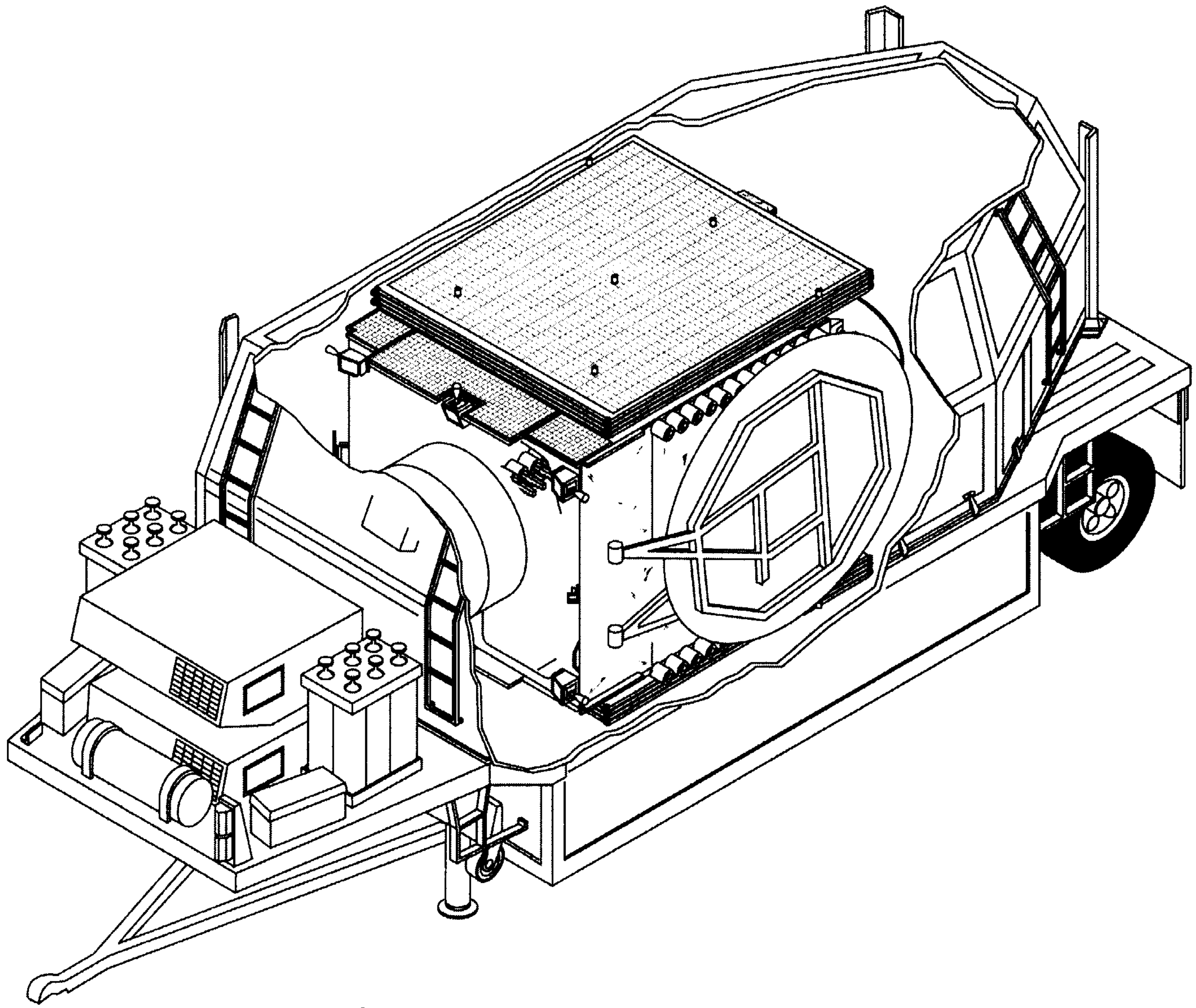
INSTALL SPACECRAFT ON TRANSPORTER
FOR SHIPMENT ON AIRPLANE

2005271

ATTACHMENT (1)

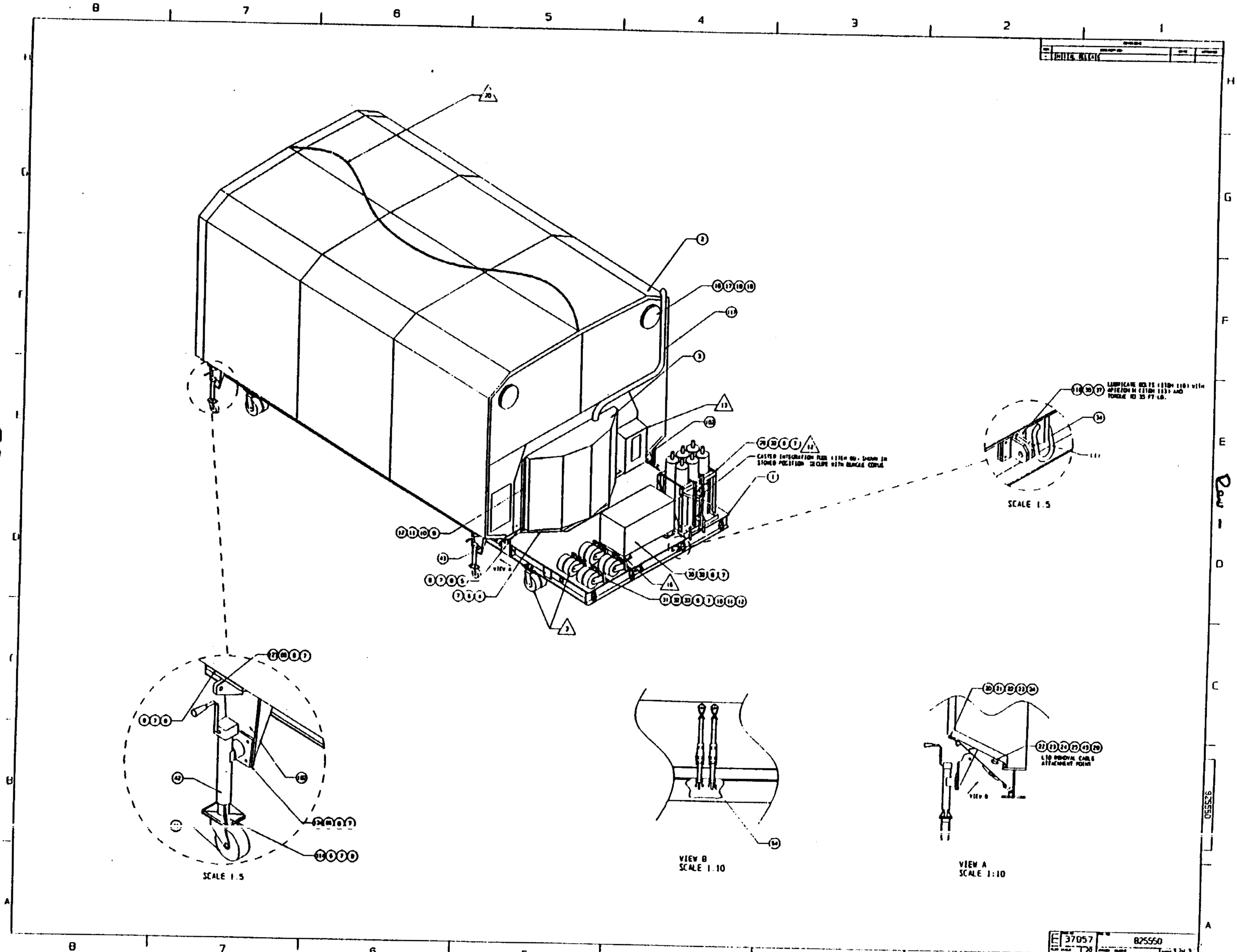


Typical Spacecraft Shipping Container being prepared for air travel



INSTALL SPACECRAFT ON TRANSPORTER
FOR SHIPMENT ON AIRPLANE

2005271



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VIEW B
SCALE 1:10
VIEW A
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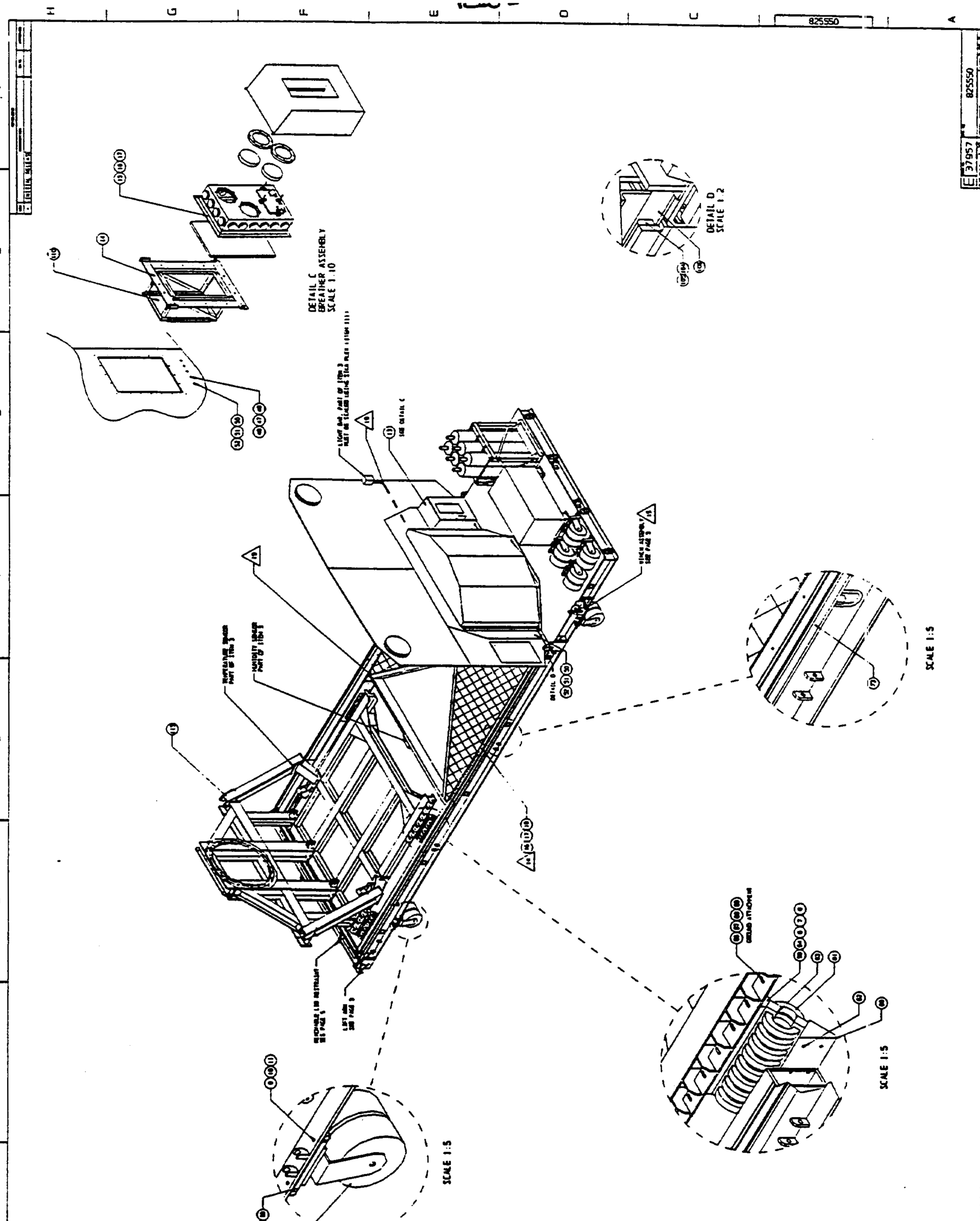
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DETAIL C
BREATHER ASSEMBLY
SCALE 1:10
DETAIL D
SCALE 1:2
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825550

NOTES:

1. DIMENSIONS GIVEN ARE REFERENCE DIMENSIONS.
2. HARDWARE SHOULD BE MINIMUM GRADE 5 STEEL AND PLATED
3. THE CONTAINER CASTERS (ITEM 38) ARE SHOWN IN BOTH THE INSTALLED AND STOWED CONFIGURATIONS. SECURE COVER ITEM 118 OVER CASTERS IN STOWED POSITION.
4. USE SEALANT (ITEM 111) TO SEAL ALL GAPS INCLUDING SPACES AROUND BOLTS AND WASHERS BUT EXCLUDING AREAS SEALED BY THE INFLATABLE SEAL OR GASKETS
5. USE LOCTITE (ITEM 112) ON BOLTS FOR WHICH NO LOCKING HARDWARE IS SPECIFIED.
6. USE APIEZON GREASE (ITEM 113) TO LUBRICATE HARDWARE WHERE REQUIRED, ESPECIALLY FOR STAINLESS ON STAINLESS.
7. HARDWARE TO BE TORQUED ACCORDING TO TORQUE TABLE UNLESS OTHERWISE INDICATED. VALUES IN TORQUE TABLE ARE NON-FLIGHT AND DO NOT INCLUDE RUNNING TORQUE.
8. DETAILED ASSEMBLY AND HANDLING INSTRUCTIONS FOR CRITICAL ITEMS CAN BE FOUND IN THE SCSP'S MANUAL 825304.
9. ITEM 91 IS TO BE CUT FROM A 150' LENGTH OF CABLE. USE ONE THIMBLE (ITEM 92) AND TWO ROPE CLIPS (ITEM 93) SPACED 2-1/4" APART PER CABLE ASSEMBLY. SOLDER THE ENDS OF THE CABLE TO PREVENT FRAYING.
10. ALL PROOFLOADS TO BE CARRIED OUT IN THE PRESENCE OF SPAR QUALITY ASSURANCE. PROOFLOADS ARE TO BE HELD FOR A MINIMUM OF TWO MINUTES. EACH PROOFLOADED ITEM IS TO BE LABELLED WITH THE FOLLOWING INFORMATION:

    ITEM NAME
    DATE OF PROOFLOAD
    PROOFLOAD
    SAFE WORKING LOAD (5 x PROOFLOAD)

11. PROOFLOADING OF THE LID INTERFACES AND LIFT POINTS ARE OUTLINED IN A SEPARATE PROOFLOAD PROCEDURE. LABELLING OF EACH PROOFLOADED ITEM WILL BE AS OUTLINED IN NOTE 10. REFER TO AIT PLAN 825003
12. SECURE COVER ITEM 119 OVER NITROGEN BOTTLES AND CASTER INTEGRATION TOOL WHEN STOWED
13. SECURE COVER ITEM 120 OVER BREATHER SHIELD
14. HARDWARE USED TO SECURE LID BRACE (PART OF ITEM 2) IN STOWED POSITION.
15. LEFT HAND WINCH INSTALLED AS PURCHASED (ITEM 84). TO OBTAIN THE CORRECT HANDLE ORIENTATION FOR THE RIGHT HAND WINCH REMOVE SHAFT AND INSTALL MODIFICATION KIT (ITEM 125).
16. SECURE COVER ITEM 126 OVER TOOL BOX.
17. FRONT BULKHEAD GROUND BRAID (ITEM 127) TO BE BOLTED FROM FLANGE BOLT TO TREAD PLATE SUPPORT ANGLE HARDWARE
18. SIDE GROUND BRAID TO BE MOUNTED USING HOIST RING HARDWARE (OUTSIDE) AND CONNECTED TO FRONT BULKHEAD WHEN IT IS CLOSED USING MAN DOOR HARDWARE (OUTSIDE)
19. ALL ELECTRICAL WIRING SHALL BE INSIDE PVC CONDUIT OR SECURED TO TIE MOUNT AND TIE WRAPS
20. SAFETY LANYARD (PART OF ITEM 2) MUST BE INSTALLED FOR PERSONNEL SAFETY.

TORQUE TABLE

NOM BOLT Ø	TORQUE
1/4	80 (IN-LB)
5/16	120
3/8	18 (FT-LB)
1/2	45
5/8	80
3/4	157

VALUES LISTED ARE NON-FLIGHT

ITEM	QTY	ZONE	DESCRIPTION	MATERIAL
133	4	5-G3	5/8-18 UNC x 1-1/2 HEX CAP SCREW	SEE NOTE 2
132	2		80-32 x 1/2 LG SCREW	
131	1		HANDLE, STEEL	
130	A/R		CABLE TIE MOUNTING DEVICE	
129	A/R		CABLE TIE, LOCKING BUNDLE SIZE 1/16"-3/4" DIA	
128	1		ELECTRICAL EXTENSION CHORD	
127	2	4-H5	GROUND BRAID	
126	1	2-G4	COVER (TOOL BOX) OZ VCP BLUE FS 14 HEIGHT x 28 x 50 C/W DRAW STRINGS AND RINGS	
125	1	5-A4	RIGHT HAND WINCH MODIFICATION KIT LSS-GSE-21	
124	4	2-H7	JACK ADAPTER BRACKET 825552-7-4	
123	4	2-H7	JACK LIFTING LUG 825552-1-4	
122	A/R	4-C2	#10 x1/2 LG SELF TAPPING SCREW	18-8
121	1	4-C2	PLENUM ASSY LSS-GSE-22	
120	1	2-G4	COVER (BREATHER SHIELD) 20 OZ VCP BLUE FS 11 HEIGHT x 31 x 22 C/W DRAW STRINGS AND RINGS	
119	1	2-G4	COVER (NITROGEN BOTTLES) 22 OZ VCP BLUE FS 80 HEIGHT x 32 x 34 C/W DRAW STRINGS AND RINGS	
118	1	2-H5	COVER (CASTERS) 20 OZ VCP BLUE FS 14 HEIGHT x 28 x 40 C/W DRAW STRINGS AND RINGS	
117	1	2-H4	HUFFER EXTENSION LSS-GSE-22	
116	16	2-E2	3/8-16 UNC x 1-1/4 HEX CAP SCREW	GR 8 STEEL
115	1	3-G3	L-FRAME 825950	
114	16	2-B0	1/2-13 UNC x 1-1/4 HEX CAP SCREW	SEE NOTE 2
113	A/R	A/S	APIEZON N LUBRICANT	
112	A/R	A/S	LOCTITE THREADLOCKER 242	
111	A/R	A/S	SIKA SIKAFLEX-221 ELASTIC ADHESIVE SEALANT	
110	300	A/S	DESICCANT (10 UNIT BAGS)	
109	2	4-G3	GRATING SUPPORT I 825552-5-1	
108	2	4-G3	GRATING SUPPORT III 825552-5-4	
107	2	4-G3	GRATING SUPPORT II 825552-5-2	
106	8	3-C2	UHMW BASE 825552-2-6	
105	2	3-C3	UHMW SIDE 2 825552-2-5	
104	4	3-C2	UHMW SIDE 1 825552-2-2	
103	2	5-C7	SAFETY SNAP PIN MONASTER CARR 90416A125	
102	2	2-E4	JACK INTERFACE BRACKET-2 825552-1-2	
101	1	5-B1	CASTER INTEGRATION TOOL LEVER ARM 825662-6-2	
100	2	5-G2	4mm HITCH PIN CLIP SPAE NALD 080-002	SEE NOTE 2
99	1	5-B2	CASTER INTEGRATION TOOL MAIN STRUCTURE 825552-6-1	
98	4	5-C4	1/4-20 UNC x 5/8 SOCKET HEAD CAP SCREW	SEE NOTE 2
97	1	5-C4	TOGGLE CLAMP CENTURY TOOLS 5.250	STEEL
96	12	5-C3	1/2-13 HEX JAM NUT	SEE NOTE 2
95	1	5-C3	HINGE PIN 825552-8-3	
94	2	5-C8	CARABINER NBC 4004-003	
93	4	5-C8	1/4 WIRE ROPE CLIP PRINCESS AUTO 3670000	
92	2	5-C8	1/4 WIRE ROPE THIMBLE PRINCESS AUTO 3820420	
91	2	5-C8	7x19 GALVANIZED CABLE 1/4" x 60' PRINCESS AUTO 3021106	
90	1	5-C7	MIRROR IMAGE PULLEY BRACKET 825552-3-9	
89	1	5-C7	PULLEY BRACKET 825662-3-6	
88	2	5-C7	3-1/2 SWIVEL EYE PULLEY PRINCESS AUTO 3001401	
87	8	5-B5	1/2 x 1/2 LG SHOULDER BOLT 3/8-16 UNC	SEE NOTE 2
86	1	5-B5	LEFT WINCH SUPPORT 825552-2-4	
85	1	5-B5	RIGHT WINCH SUPPORT 825552-2-1	
84	2	5-B5	HAND WINCH PRINCESS AUTO P/N 1510130	
83	34	5-E3	1/4-20 UNC x 5/8 FLAT HEAD SOCKET CAP SCREW	SEE NOTE 2
82	[illegible]	[illegible]	1/4-20 UNC x 1 SOCKET HEAD CAP SCREW	SEE NOTE 2
81	4	5-A4	7/8 SHACKLE CROSBY 1018623	STEEL

ITEM	QTY	ZONE	DESCRIPTION	MATERIAL
80	8	5-E2	STOPPER 825552-3-5	
79	4	5-E2	LOWER SPACER 825552-3-4	
78	4	5-E2	BOTTOM SPACER 825552-3-1	
77	8	5-E3	SIDE SPACER 825552-3-2	
76	4	5-E3	TOP SPACER 825552-3-3	
75	2	5-E3	LIFT ARM 825552-3-7	
74	2	5-E3	LIFT ARM 825552-3-8	
73	20	3-F5	1/4-20 UNC x 1 FLAT HEAD SOCKET CAP SCREW	SEE NOTE 2
72			DELETED	
71	8	3-F0	SPRING PLUNGER P/N REID TOOL P/N PP-30	STEEL
70	1	5-G0	POLYVALLE LID RESTRAINT 825552-4-2	
69	1	2-B0	1/2-13 UNC HEX NUT	SS
68	2	2-B0	1/2 NOM DIA LOCK WASHER	SS
67	4	2-B0	1/2 NOM DIA FLAT WASHER	SS
66	1	2-B0	1/2-13 UNC x 1-1/2 SOCKET HEAD CAP SCREW	SS
65	20	2-B0	1/2-13 UNC x 1 SOCKET HEAD CAP SCREW	SS
64	16	2-B8	1/2-13 UNC x 3.0 SOCKET HEAD CAP SCREW	UNBRAKO
63	32	2-B0	3/4-10 UNC x 3 FLAT HEAD SOCKET CAP SCREW	UNBRAKO
62	32	2-B7	3/4-10 UNC x 1-3/4 SOCKET HEAD CAP SCREW	UNBRAKO
61	4	2-B0	COIL SPRING ISOLATOR AEROFLEX CB-2000-10-E2	STEEL
60	4	2-B7	LOWER ISOLATOR BRACKET 825008-2	
59	4	2-B0	UPPER ISOLATOR BRACKET 825008-1	
58	10	4-E3	1/4-20 UNC x 1.25 SOCKET HEAD CAP SCREW	SEE NOTE 2
57	4	4-E3	GRATING 825552-5-3	
56	30	4-E3	3/8-16 UNC x 1-3/4 HEX CAP SCREW	SEE NOTE 2
55	30	4-E3	3/8-16 UNC HEX NUT	SEE NOTE 2
54	14	2-B3	1/2 SHACKLE CROSBY 1018472	STEEL
53			DELETED	
52	2	3-F3	3/4 PLUG SWAGELOK SS-1210-P	SS
51	4	3-F3	3/4 AN ADAPTOR SWAGELOK SS-12-TA-1-12AN	SS
50	2	3-F3	3/4 BULKHEAD UNION SWAGELOK SS-1210-61	SS
49			DELETED	
48	3	3-F3	1/2 PLUG SWAGELOK SS-810-P	SS
47	8	3-F3	1/2 AN ADAPTOR SWAGELOK SS-8-TA-1-8AN	SS
46	3	3-F3	1/2 BULKHEAD UNION SWAGELOK SS-810-61	SS
45	2	2-E1	SPACER 825662-3-3	SS
44			DELETED	
43	2	2-E0	JACK L/F BRACKET-1 825552-1-1	
42	4	2-E7	MODIFIED JACK 825552-1-2	
41	4	2-E7	COLSON SWIVEL LOCK CASTER 8 4250 060	
40	16	3-F0	5/8-11 UNC x 1-3/4 HEX CAP SCREW	SEE NOTE 2
39	4	3-F0	CASTER L/P PLATE 825662-2-3	
38	4	3-F0	ALBION SWIVEL LOCK CASTER 265 PV 1780057PL	
37	78	2-E2	3/8 NOM DIA LOCK WASHER	SEE NOTE 2
36	126	2-E2	3/8 NOM DIA FLAT WASHER	SEE NOTE 2
35	10	2-E2	3/8-16 UNC x 1-1/4 HEX CAP SCREW	SEE NOTE 2
34	1	2-E2	TOW POINT 825552-4-3	
33	8	2-D4	5/8-11 UNC x 3 HEX CAP SCREW	SEE NOTE 2
32	22	2-D4	1/2-13 UNC x 2 HEX CAP SCREW	SEE NOTE 2
31	2	2-D4	CASTER STORAGE SUPPORT 825662-3-10	
30	1	2-D4	TOOL BOX ASSEMBLY 825937	
29	1	2-D4	NITROGEN RACK ASSEMBLY 825660	
28	14	2-C4	LID TIE DOWN STRAP ASSEMBLIES [illegible]	
27	4	4-D3	1/4-20 UNC NYLON LOCK NUTS	SEE NOTE 2
26	4	4-D3	1/4-20 UNC x 3-1/2 HEX CAP SCREW	SEE NOTE 2
25	4	2-C3	5/16-18 UNC x 2-3/4 SOCKET HEAD CAP SCREW	SEE NOTE 2
24	60	2-C3	5/16-18 UNC HEX NUT	SEE NOTE 2
23	60	2-C3	5/16 NOM DIA LOCK WASHER	SEE NOTE 2
22	60	2-C3	5/16 NOM DIA FLAT WASHER	SEE NOTE 2
21	16	2-C3	5/16-18 UNC x 1-3/4 SOCKET HEAD CAP SCREW	SEE NOTE 2
20	4	2-C2	HOIST RING PEIO TOOL P/N SHR 34030	STEEL
19	2	2-H4	KRUNCHEY ADAPTOR	
18	20	2-H0	1/4-20 UNC HEX NUT	SEE NOTE 2
17	78	2-H0	1/4 NOM DIA LOCK WASHER	SEE NOTE 2
16	110	2-H0	1/4 NOM DIA FLAT WASHER	SEE NOTE 2
15	10	2-H0	1/4-20 UNC x 1-3/4 HEX CAP SCREW	SEE NOTE 2
14	172	2-H0	1/4-20 UNC x 1-1/4 FLAT HEAD SOCKET CAP SCREW	SEE NOTE 2
13	1	3-F3	BREATHER ASSEMBLY 825581	
12	17	2-D8	5/8-11 UNC HEX NUT	SEE NOTE 2
11	40	2-D5	5/8 NOM DIA LOCK WASHER	SEE NOTE 2
10	40	2-D5	5/8 NOM DIA FLAT WASHER	SEE NOTE 2
9	20	2-D5	5/8-11 UNC x 2-1/4 HEX CAP SCREW	SEE NOTE 2
8	60	2-D5	1/2-13 UNC HEX NUT	SEE NOTE 2
7	114	2-D5	1/2 NOM DIA LOCK WASHER	SEE NOTE 2
6	120	2-D5	1/2 NOM DIA FLAT WASHER	SEE NOTE 2
5	2	2-B0	1/2-13 UNC x 2-3/4 HEX CAP SCREW	SEE NOTE 2
4	2	2-B0	1/2-13 UNC x 1-3/4 HEX CAP SCREW	SEE NOTE 2
3	1	2-G4	MODIFIED THERMO KING [illegible]	
2	1	2-H4	CONTAINER LID FABCD P/N 51824-1660	
1	1	2-H4	BASE WELDMENT 825551	

BILL OF MATERIAL

Spar Aerospace Limited

LORAL S/C SHIPPING CONTAINER ASSEMBLY

825550

- LS -

PRESSURANT TANK DRAWINGS

E137830-01
E137830-02

ATTACHMENT (2)

REV	DESCRIPTION
2	INITIAL RELEASE

NOTES (UNLESS OTHERWISE SPECIFIED):

SOURCE CONTROL DRAWING NOTES

1. INTERPRET DRAWING PER DOD-D-1000.
2. ONLY THE ITEM DESCRIBED ON THIS DRAWING WHEN PROCURED FROM THE VENDOR(S) LISTED HEREON IS APPROVED BY SPACE SYSTEMS/LORAL PALO ALTO, CALIFORNIA FOR USE IN THE APPLICATION(S) SPECIFIED HEREON. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY SPACE SYSTEMS/LORAL, PALO ALTO, CALIFORNIA.
3. IDENTIFICATION OF APPROVED SOURCE(S) HEREON IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTUNUED AVIALABILITY AS A SOURCE OF SUPPLY FOR THE ITEM DESCRIBED ON THIS DRAWING.
4. CLEAN, HANDLE AND PROTECT TO MEET MIL-STD-1246.
5. THE FOLLOWING ABBREVIATIONS ARE USED:

   MAXIMUM EXPECTED OPERATING PRESSURE: MEOP
   HELIUM: He
   XENON: Xe

6. UNIT REFERENCE DESIGNATORS: He 536A, 536B
   Xe 5198A, 5198B
7. CENTER GRAVITY: ⊕ ± .315 IN.
8. UNIT WEIGHT: ±5% -01 (He) 22.6 lb -02 (Xe) 19.0 lb
9. PRESSURE RATINGS

	-01	-02
A. OPERATING:	0 TO 4000 PSI MAX	0 TO 2700 PSI MAX
B. PROOF:	5200 PSI MIN	3375 PSI MIN
C. BURST:	6000 PSI MIN	4050 PSI MIN

10. EXTERNAL LEAKAGE:

    1.0×10^{-6} SCC/S He AT MEOP WITH 100% He, OR
    1.0×10^{-7} SCC/S He AT MEOP WITH 10% He/90% NITROGEN MIX.

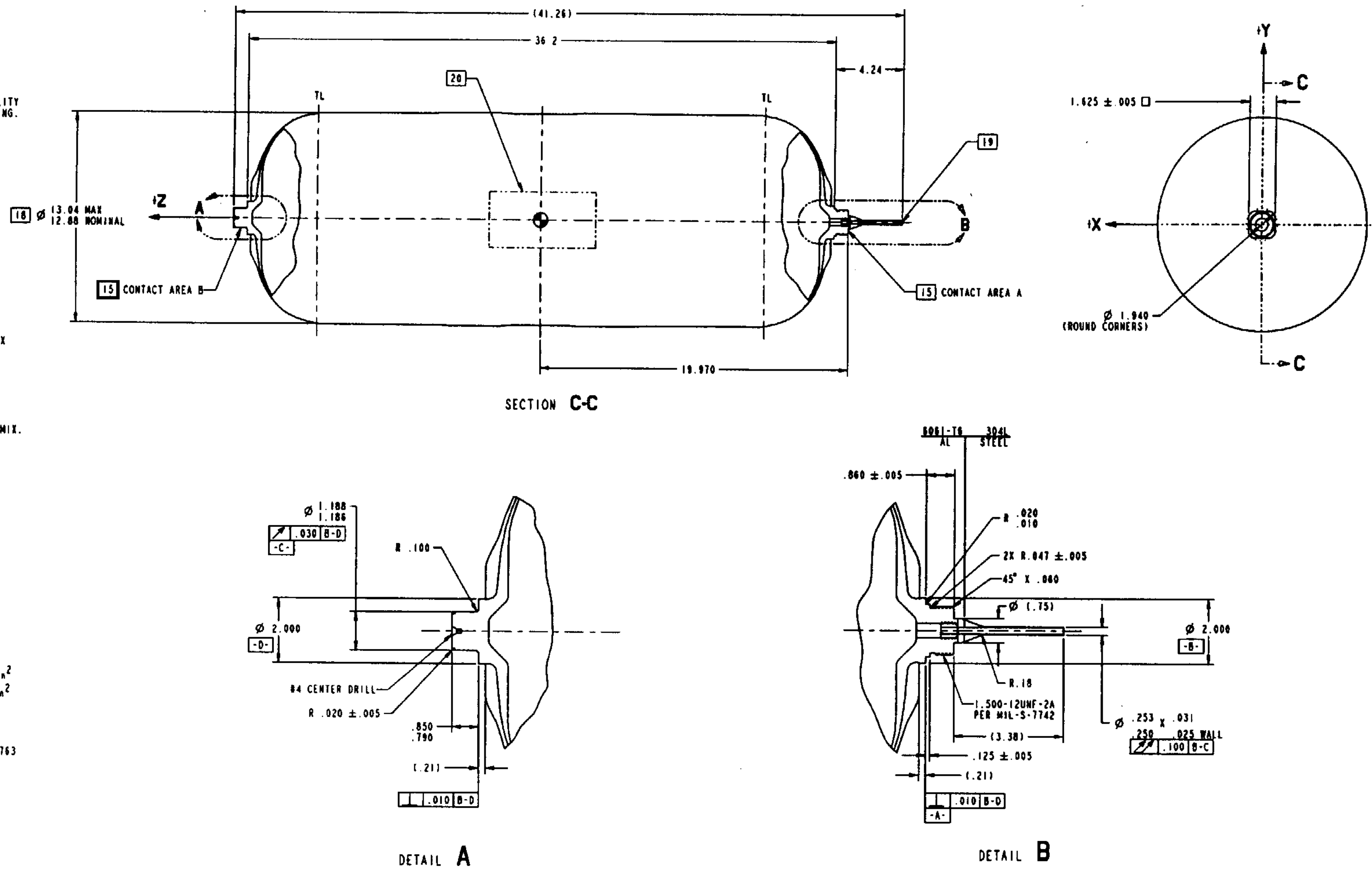
11. TEMPERATURE

    REFER TO SPECIFICATION.

12. VOLUME:

    A. NOMINAL: 4000 in^3
    B. MIN. UNPRESSURIZED: 3995 in^3
    C. TYPICAL INCREASE AT: 4000 PSI IS 82 in^3 FOR -01
    2700 PSI IS 72 in^3 FOR -02

13. OPERATING FLUID: -01 HELIUM PER MIL-PRF-27407
    -02 XENON
14. PERFORMANCE SPECIFICATION: -01 E125301
    -02 E172856
15. MOUNTING SURFACE CONTACT AREA: -01 A=.80 in^2 B=2.09 in^2
    -02 A=2.04 in^2 B=2.09 in^2
16. MATERIAL:
    TUBE: Ø6.35 X 0.71 [.250 X .028] WALL THK. TYPE 304L SEAMLESS CRES TUBING PER SAE AMS-QQ-S-763 EXCEPT CARBON CONTENT SHALL NOT EXCEED .025%
    LINER: ALUMINUM 6061-T6 (NO FINISH)
    WRAP: GRAPHITE
17. ALL DIMENSIONS SHOWN ARE IN THE UNPRESSURIZED CONDITION UNLESS OTHERWISE NOTED.
    TYPICAL LENGTH INCREASE AT 4000 PSIG IS .255 FOR -01
    TYPICAL LENGTH INCREASE AT 2700 PSIG IS .270 FOR -02
18. CYLINDER DIAMETERS MEASURED BY PI TAPE.
19. TUBE SHALL BE FITTED WITH SWAGELOK 1/4 in. END CAP FITTING (SS-400-CAK). NUT & NYLON FERRULE (OR EQUIVALENT) TO KEEP POSITIVE PRESSURE IN TANK FOR STORAGE. ITEMS NOT SHOWN FOR CLARITY.
20. MARK: PART NAME, SS/L PART NUMBER, SPECIFICATION NUMBER, ITEM SERIAL NUMBER, MANUFACTURER'S NAME AND CAGE CODE, DATE OF MANUFACTURE AND CONTRACT NUMBER APPROXIMATELY WHERE SHOWN PER MIL-STD-130.
21. MOMENT OF INERTIA ABOUT CENTER OF GRAVITY: N/A.



-01 HELIUM

STAGE III RELEASE

INTERFACE CONTROL DRAWING
SOURCE CONTROL DRAWING

APPROVED SOURCE OF SUPPLY			
VENDOR	VENDOR ITEM IDENTIFICATION	MEDIUM	SSL PART NO
LINCOLN COMPOSITES	220145	HELIUM	E137830-01
CAGE CODE: 17996	220142	XENON	E137830-02

02	E169600	COMMON PRODUCTS	
01	E169600	COMMON PRODUCTS	
DASH	NEXT ASSY	USED ON	
APPLICATION			

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED: INTERPRET PER DOD-D-1000 LEVEL 3. DIMENSIONS IN INCHES IN ACCORDANCE WITH ANSI Y14.5M-1982. DRILL TOLERANCES ARE PER AND10387

TOLERANCES: DEC .X ± .060 DEC .XX ± .03 DEC .XXX ± .010 FRACTIONS ± — ANGLES ± 2°

J. SHAPIRO 00-03-09 | CONTRACT NO. COMMON PRODUCTS | 31 | ZE | ~~SEE SEPARATE PARTS LIST~~

Following Approvals Controlled By PDM System

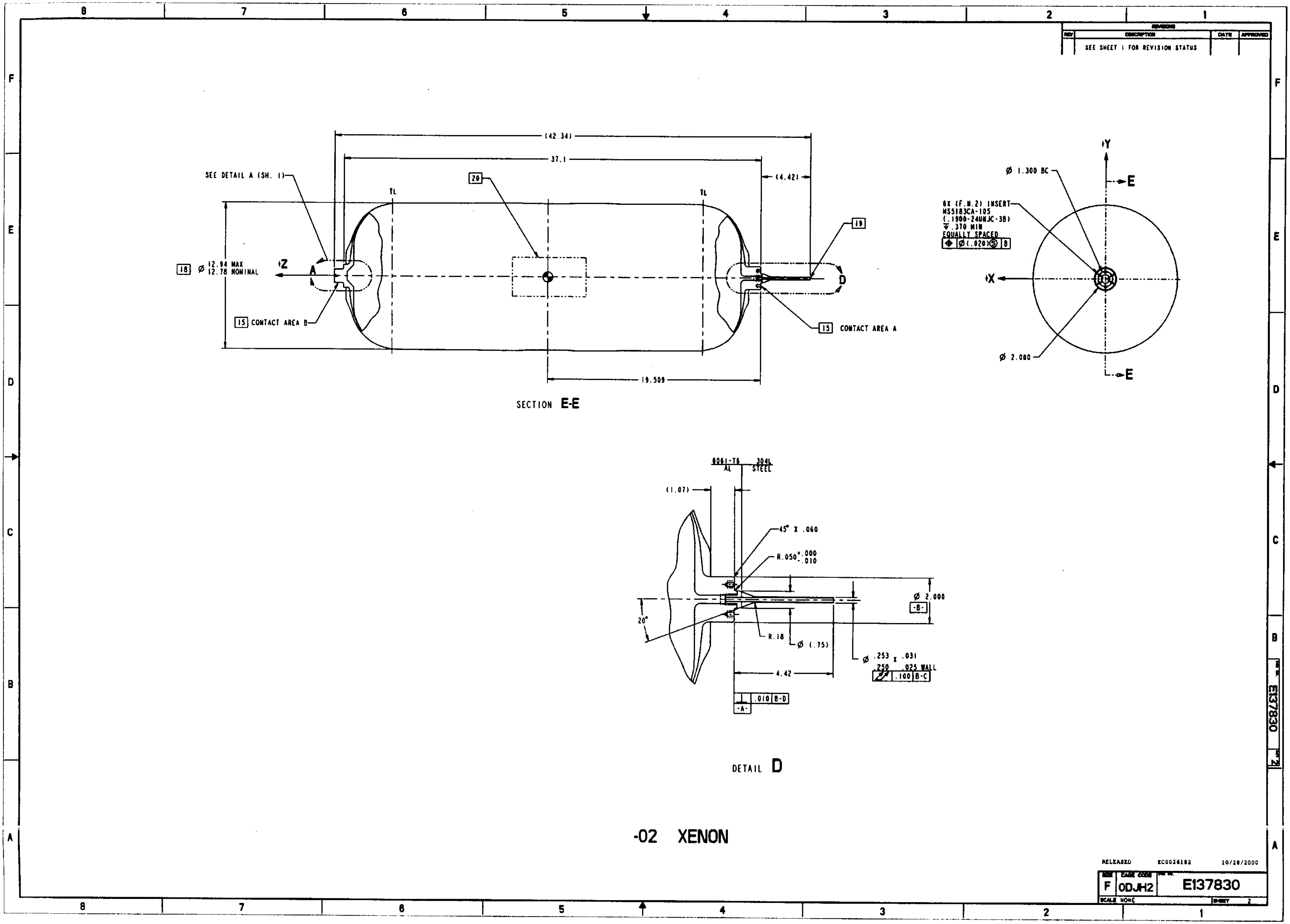
Function	Approver Name	Approved
SUBSYSTEM MGR	Randolph T	10/24/2000
SUBSYSTEM MGR	Rogers W	10/26/2000
RESP. ENG.	Lee J	10/26/2000
SYS. ENG. MECH.	Szeto B	10/27/2000
MASS PROP. ENG.	Froehlich M	10/27/2000
HARNESS ENG.	Breitels B	10/27/2000
MECH. ENG.	Kasai H	10/27/2000
THERMAL ENG.	Pon R	10/27/2000
S/C CONFIG.	Bugui P	10/27/2000
SYS. ENG. ELEC.	Pidgeon C	10/27/2000
SUBCON ENG.	James D F	10/27/2000
SYS. ENG. MNGR.	Pon R	10/27/2000
CIS	Tindall T	10/27/2000
EDRC	Allison U	10/28/2000

SPACE SYSTEMS/LORAL

TANK, PRESSURANT, HELIUM/XENON

SIZE F | CAGE CODE 0DJH2 | DWG NO. E137830

SCALE NONE | SHEET 1 OF 2



SEE SHEET 1 FOR REVISION STATUS
(42.34)
37.1
(4.42)
SEE DETAIL A (SH. 1)
20
TL
TL
19
18 Ø 12.94 MAX 12.78 NOMINAL
+Z
A
D
15 CONTACT AREA B
15 CONTACT AREA A
19.509
SECTION E-E
+Y
Ø 1.300 BC
E
E
8X (F.N.2) INSERT MS5183CA-105 (.1900-24UNJC-3B) .370 MIN EQUALLY SPACED
Ø (.020) S B
+X
Ø 2.000
6061-T6 AL
304L STEEL
(1.07)
45° X .060
R.050 +.000 -.010
Ø 2.000
-B-
20°
R.18
Ø (.75)
Ø .253 X .031 .250 .025 WALL
.100 B-C
4.42
.010 B-D
-A-
DETAIL D
-02 XENON
RELEASED EC0026182 10/28/2000
F 0DJH2 E137830
SCALE NONE SHEET 2

PRESSURANT TANK QUALIFICATION REPORT

HELIUM 65 L

Lincoln Composites
19410-53000-1

ATTACHMENT (3)

Report Number: 19410-53000-1
Date: 9 June 2000
Revision: NC

QUALIFICATION TEST REPORT

For

4000 ci HELIUM TANK

Space Systems/LORAL Part Number E137830-01
Lincoln Composites Part Number 220145-1
Serial Number 003

Per

Space Systems/LORAL
Performance Specification E125301
Revision 1

Written By:

Bob Loibl
Test Engineer

Reviewed By:

G. B. Khawand
Gerges Khawand
Design Engineer

Reviewed By:

Dan Nissen
Dan Nissen
Manufacturing Engineer

Approved By:

C. F. Murray
Con Murray
Program Manager

REVISION PAGE

Revision Number	Date	Comments
NC	9 Jun 00	Initial Release

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 The purpose of this test report is to present the test requirements for, test procedures used, and test results obtained during the performance of a Qualification Test Program conducted on one (1) filament-wound, 4000 cubic inch Helium Tank Assembly, Lincoln Composites Part Number 220145-1, Serial Number 003.

1.2 The purpose of the test program, performed on a tank assembly representative of flight (deliverable) hardware, was to qualify the tank assemblies for their intended use in systems for which they were designed.

1.3 The Qualification Test Program was conducted to demonstrate compliance with the requirements of Space Systems/LORAL Performance Specification Number E125301, Revision 1 (Reference 2.1). Tests were conducted in accordance with Lincoln Composites Quality Control Procedure Number QCP-06-744 (Reference 2.2) and Wyle Laboratories Procedure Number 5081 (Reference 2.4). Tests were performed at Lincoln Composites in Lincoln, Nebraska and Wyle Laboratories, El Segundo, California.

1.4 The Qualification Test Program, shown in the Table 1 Qualification Test Matrix, is summarized in Paragraph 3.0; detailed test requirements, test procedures and test results are presented in Paragraph 5.0 and attachments to this document.

TABLE 1
QUALIFICATION TEST MATRIX

Test Title	Sequence Number	Report Number (1)	Ref. 2.1 Paragraph (2)	Ref. 2.2 Paragraph (3)	Ref. 2.3 Paragraph (4)
Acceptance Test	1	5.1	4.3.5	5.1	---
Pressure Cycle Helium Leakage	2	5.2	4.3.6.1	5.2	---
Precision Cleaning	3	5.3	4.3.5.3	5.3	---
Dynamics Clean Verification Helium Leakage	4	5.4	4.3.6.2	5.4	All
Burst	5	5.5	4.3.6.3	5.5	---

(1) This document, Report Number 19410-53000-1
(2) Space Systems/LORAL Performance Specification E125301
(3) Lincoln Composites Quality Control Procedure QCP-06-744
(4) Wyle Laboratories Dynamics Procedure 5081

2.0 REFERENCE DOCUMENTS

2.1 Space Systems/LORAL Performance Specification Document Number E125301, Revision 1, titled: Helium Tank, Performance Specification

2.2 Lincoln Composites Quality Control Procedure Number QCP-06-744, Revision A, titled: Qualification Test Procedure, Lincoln Composites Part Number 220145-1

2.3 Lincoln Composites Quality Control Procedure Number QCP-06-743, Revision A, titled: Acceptance Test Procedure, Lincoln Composites Part Number 220145-1

2.4 Wyle Laboratories Test Procedure Number 5081, Revision A, titled: Qualification Sinusoidal and Random Vibration of One Each Xenon and Helium Storage Tanks, Part Numbers 220142-1 and 220145-1

2.5 National Technical Systems Precision Cleaning Procedure Number 3898, Revision NC, titled: Cleaning, Inspection and Sealing of Tank Assemblies for Space Systems Loral

3.0 SUMMARY

3.1 One (1) filament-wound Helium Tank assembly, hereafter identified as tank, was submitted for testing in the Qualification Test Program. The tank was representative of production units and was identified as Lincoln Composites Part Number 220145-1, Serial Number 003. The tank was subjected to testing as summarized in Paragraphs 3.1.1 through 3.1.5.

3.1.1 **Acceptance Testing** - The tank was subjected to acceptance test procedures in accordance with Paragraph 5.1 of QCP-06-744 (Reference 2.2). The acceptance test procedures consisted of proof pressure-volume testing, helium leakage testing, and dimensional inspection. After completion of the acceptance testing, the tank was subjected to pressure cycle testing.

3.1.2 **Pressure Cycle Test** - The tank was subjected to pressure cycle testing in accordance with Paragraph 5.2 of QCP-06-744 (Reference 2.2). The pressure cycle testing consisted of 4 hydrostatic cycles from 0 to 5200 psig, 8 hydrostatic cycles from 0 to 4400 psig, and 40 hydrostatic cycles from 0 to 4000 psig. After completion of the pressure cycle testing, the tank was helium leak tested to 4000 psig, 10% helium and 90% nitrogen mixture, and was then subjected to precision cleaning.

3.1.3 **Precision Cleaning** - The tank was precision cleaned in accordance with Paragraph 5.3 of QCP-06-744 (Reference 2.2) by National Technical Systems (NTS), Los Angeles, California. After precision cleaning, the tank was forwarded to Wyle Laboratories for dynamics testing.

3.1.4 **Dynamics Testing** - The tank was subjected to sinusoidal and random vibration testing in accordance with Wyle Laboratories Procedure Number 5081 (Reference 2.3). The dynamics testing consisted of sinusoidal and random vibration in the longitudinal axis and one radial axis while pressurized to 4000 psig with helium gas. After dynamics testing, the tank was subjected to a cleanliness verification check by NTS and helium leakage testing by Lincoln Composites. After completion of the post-dynamics leak test, the tank was subjected to burst pressure testing.

3.1.5 **Burst Pressure Testing** - The tank was subjected to burst testing in accordance with Paragraph 5.5 of QCP-06-744 (Reference 2.2). The burst test consisted of hydrostatically pressurizing the tank from 0 psig to catastrophic failure, with a maximum 5 second hold at 4000 psig. The tank developed leakage at 6500 psig, subsequent pressurization to 7010 psig did not result in catastrophic failure of pressurization to 7010 psig did not result in catastrophic failure of the tank. The test was aborted when the leak rate exceeded the capability of the test system to continue pressurization.

3.2 The tank complied in all aspects to the requirements of Space Systems/LORAL Performance Specification E125301 (Reference 2.1) with the exception of the post-vibration test cleanliness verification (see Paragraph 5.3). Prior to the burst test, the tank exhibited no evidence of deterioration, detrimental structural deformation, leakage beyond specification requirements, or other damage as a result of the imposed testing.

3.3 Serial Number 003 incorporated a design iteration dictated by the qualification test failure of Serial Number 002. Serial Number 002 exhibited water leakage after the completion of 67 hydrostatic pressure cycles (of the then required 72 cycles) at MEOP. Investigation of the Serial Number 002 failure indicated that the large grain size of the forged aluminum liner was the major contributing factor. The tank liner was redesigned as a three-piece unit using port and blank liner halves machined from previously qualified Tempo pressure vessel forgings. A cylindrical section, 8.25" in length, machined from an identical qualified Temo forging, was welded between the port and blank liner halves to obtain the specification requirement 4000 cubic inch volume. In addition to the redesign of the tank liner, the Reference 2.1 specification requirement for qualification pressure cycling was reduced in scope. The cycle life requirements were: 8 cycles at 1.25 X MEOP, 8 cycles at 1.1 X MEOP and 72 cycles at MEOP. The cycle life requirements are now: 4 cycles at 1.25 X MEOP, 8 cycles at 1.1 X MEOP and 40 cycles at MEOP.

3.4 The liner assembly for Part Number 220145-1, Serial Number 003, exhibited a 0.044" weld mismatch at 270° in the port-liner-half-to-cylinder-section circumferential weld, versus the Lincoln Composites drawing requirement of 0.021" maximum. The successful completion of qualification testing of Serial Number 003 that had a weld mismatch of 0.044" demonstrated the capability of the tank to satisfactorily comply with Reference 2.1 specification requirements. Acceptance limits of 0.044" maximum for flight tanks, as demonstrated by the qualification tank, will be used for as the new acceptance inspection criteria.

3.5 The test program on Serial Number 003 was initiated in May of 2000 and was completed in June of 2000.

3.6 All data obtained during the performance of Acceptance Testing and Qualification Testing is presented in Paragraph 5.0 and attachments to this document.

4.0 TEST CONDITIONS AND TEST EQUIPMENT

4.1 Test Conditions

Unless otherwise specified herein, the standard test conditions during the Qualification Test Program were an atmospheric pressure of site ambient, a temperature of 55° to 90° F and uncontrolled relative humidity.

4.2 Test Equipment

All test equipment used in the performance of testing and inspections during the Qualification Test Program, as detailed in Reference 2.2, 2.3 and 2.4, was calibrated in accordance with MIL-STD-45662. Equipment calibrations were verified as current prior to the performance of tests and inspections.

5.0 QUALIFICATION TEST PROGRAM

5.1 Acceptance Test Procedures

5.1.1 Requirements

(Reference 2.1, Paragraph 4.3.5)

5.1.1.1 Acceptance testing shall be performed in sequence specified for the tank being employed in the qualification test program. The tank shall satisfactorily complete acceptance testing prior to being placed in the qualification test program.

5.1.1.2 Each tank shall be subjected to an acceptance test consisting of:

a) Proof pressure/volume
b) Helium leakage
c) Dimensional inspection

5.1.2 Procedures

(Reference 2.2, Paragraph 5.1)

5.1.2.1 The tank was subjected to the test requirements specified in Paragraph 5.1.1. These tests were performed at and by Lincoln Composites.

5.1.2.2 The tank was subjected to acceptance testing in accordance with Reference 2.2 of this document:

a) Proof pressure testing (to 5200 psig) using deionized water per Paragraph 5.0 of QCP-06-743.
b) Volume measurements using water weight versus temperature to determine volumetric capacity (4000 cubic inches minimum volume) per Paragraph 5.0 of QCP-06-743.
c) External leakage testing using the vacuum chamber method while pressurized (to 4000 psig) with a 10% helium gas mixture (maximum leakage rate not to exceed 1×10^{-7} scc/sec) per Paragraph 7.0 of QCP-06-743.
d) Visual and dimensional inspection per Manufacturing & Inspection Record (M&IR 175199-1) processing.

5.1.3 Results

5.1.3.1 The tank complied in all aspects to the requirements of the test procedure.

5.1.3.2 Acceptance test results.

TABLE 2
ACCEPTANCE TEST RESULTS

Max. Proof Press (psig)	Post Proof Volume @ 0 psig (cubic inches)	Permanent Set (%)	Max. Leakage (scc/sec)
5206	4029.0	0.35%	3.4×10^{-8}

5.1.3.3 The test results and proof pressure traces obtained during the performance of the acceptance test procedures are presented in Appendix 1 of the document along with visual and dimensional data.

5.2 Pressure Cycle Test

5.2.1 Requirements

(Reference 2.1, Paragraph 4.3.6.1)

5.2.1.1 The tank shall be subjected to hydrostatic pressure cycling at room temperature from ambient pressure to 1.3 times MEOP, 1.1 times MEOP and MEOP using water. The number of cycles applied shall be sufficient to achieve a total of 4 each 1.3X MEOPcycles, 8 each 1.1X MEOP cycles, and 40 each MEOP cycles including all pressurizations prior to burst testing.

5.2.1.2 The tank shall be subjected to a leakage test at MEOP to verify conformance with requirements. Allowable external leakage including tank joints shall not exceed 1×10^{-7} scc/sec when pressurized with 10% helium and 90% nitrogen at MEOP.

5.2.2 Procedures

(Reference 2.2, Paragraph 5.2)

5.2.2.1 The tank was subjected to the test requirements specified in Paragraph 5.2.1. This test was performed at and by Lincoln Composites.

5.2.2.2 The tank was hydrostatically pressure cycled using deionized water. The pressures were as shown in Table 3.

TABLE 3
PRESSURE CYCLE TEST PARAMETERS

Sequence	Number of Cycles (*)	Pressure Range (psig)
A	4	0 to 5200 to 0
B	8	0 to 4400 to 0
C	34	0 to 4000 to 0
Tolerances:	+50/-0 psig at 0 psig and at peak pressure	
Ramp rate:	75 to 125 psi per second	
Hold time at peak:	5 seconds maximum	

(*) Number of 4000 psig pressure cycles reduced from 40 to 34 to compensate for expected MEOP cycles to be applied during qualification program.

5.2.2.3 The overall length differential growth and diameters effected by pressure was measured during one pressure cycle from 0 to 4000 to 0 psig. During the last cycle of pressure from 4000 to 0 psig, the effluent liquid from the tank was captured and weighed. The volume of the effluent water was calculated using water weight versus temperature times the compression factor of water at 4000 psig. The effluent volume was added to the 0 psig volume determined during acceptance testing to determine overall volume of the tank at 4000 psig.

5.2.2.4 The tank was visually examined for evidence of damage at the completion of the pressure cycles.

5.2.2.5 At the completion of pressure cycling, the tank was subjected to an external helium leakage test. The tank was placed in a vacuum chamber that was evacuated and valved into a helium mass spectrometer. The tank was pressurized to 400 (±20) psig with helium gas and then to 4050 (±50) psig with nitrogen gas. The leak detector was monitored for indications of helium leakage for a period of 15 minutes. Procedural requirements state that leakage cannot exceed 1×10^{-7} scc/sec.

5.2.3 Results

5.2.3.1 The tank complied in all aspects to the requirements of the pressure cycle test.

5.2.3.2 The tank exhibited no evidence of leakage or visual damage as a result of the cyclic pressurizations.

5.2.3.3 The overall length differential growth of the tank was 0.357 inches. The diametrical growth was 0.099 inches at the port tangent, 0.095 inches at the port girth weld, 0.059 inches at mid-cylinder, 0.089 inches at the blank girth weld, and 0.105 inches at the blank tangent.

5.2.3.4 The effluent volume of the tank, from 4000 psig to 0 psig, was 138.5 cubic inches. The total calculated volume of the tank at 4000 psig was 4167.5 cubic inches.

5.2.3.5 The tank did not leak in excess of the specification requirements. Actual measured leakage was less than 3.8×10^{-9} scc/sec.

5.2.3.6 The test results obtained during the performance of the pressure cycle testing are presented in Appendix 2 of this document.

5.3 Precision Cleaning

5.3.1 Requirements

(Reference 2.1, Paragraph 4.3.5.3)

5.3.1.1 Cleanliness of the tank shall be verified in accordance with the requirements of ARP-598 and shall meet the requirements of Paragraph 3.4.1.2 of Reference 2.1.

5.3.1.2 The interior surface of the tank shall be maintained in a cleaned condition during dynamics testing by means of an in-line filter attached to the inlet tube. The in-line filter shall not be removed until cleanliness verification following the dynamics testing has been initiated.

5.3.2 Procedures

(Reference 2.2, Paragraph 5.3)

5.3.2.1 Prior to dynamics testing, the tank was subjected to the cleaning requirements specified in Paragraph 5.3.1. At the completion of the dynamics testing, the tank was subjected to the cleanliness verification check specified in Paragraph 5.3.1. The cleaning and cleanliness verification were performed at and by NTS, Los Angeles, California.

5.3.2.2 The external surfaces of the tank were cleaned to remove dust, grease, oil and other soils.

5.3.2.3 The internal surfaces of the tank were pre-cleaned using isopropyl alcohol, Turco 4215, deionized water and gaseous nitrogen. After pre-cleaning operations were performed, the internal surfaces were precision cleaned in a Class 10,000 clean room using 0.5 micron filtered isopropyl alcohol. A 1000 milliliter sample of the effluent alcohol was then sampled for particulates.

5.3.2.4 The tank was dried in a vacuum oven at 140° F at a vacuum of 27 ±2 inches of Mercury for a minimum of 2 hours.

5.3.2.5 After removal from the drying oven, a 2 micron nominal in-line pleated mesh filter was installed on the inlet tube of the tank. The tank was then packaged in a 2-mil nylon film bag and then over-bagged with 6-mil polyethylene.

5.3.3 Results

5.3.3.1 The tank complied in all aspects to the requirements of the cleaning operations and the cleanliness verification check.

5.3.3.2 Cleaning particulate and cleanliness verification counts were as shown in Table 4.

TABLE 4
PRECISION CLEANING RESULTS

Size (microns)	Ref. 2.1 Para. 3.4.1.2 Reqmt's	Initial Clean Results (pre-vibr.)	Cleanliness Verification (post-vibr.) (1)
	(per 100 ml)		
<5	No silting	No silting noted	No silting noted
5 to 10	600	345	920
11 to 25	100	71	560
26 to 50	25	18	230
51 to 100	4	2	118
>100	0	0	7
NVR (2)	<1.0 mg	0.5 mg	Not taken

(1) 10% of particles over 25 microns were metallic
(2) NVR not a requirement per Reference 2.1, Paragraph 3.4.1.2

5.3.3.3 The cleaning certifications and particulate count data sheets obtained during the performance of these operations are presented in Appendix 2 of this document.

5.3.3.4 Due to the fact that the post-vibration test particulate counts exceeded the Reference 2.1, Paragraph 3.4.1.2, requirements, the first production flight tank will be subjected to acceptance vibration testing with pre-test cleaning and post-test cleanliness verification being performed.

5.4 Dynamics Testing

5.4.1 Requirements

(Reference 2.1, Paragraph 4.3.6.2)

5.4.1.1 The tank shall be subjected to dynamics testing while pressurized with helium to MEOP with the tank end bosses attached to a rigid fixture.

a) A vibration survey of the test fixture, with the tank mounted, shall be performed by swept sinusoid or low level random applied I the longitudinal direction and one lateral direction
b) Random vibration shall be applied consecutively in the longitudinal direction and one lateral direction at levels specified in Table VI of Reference 2.1.
c) Sinusoidal vibration shall be applied consecutively in the longitudinal direction and one lateral direction at levels specified in Table VI of Reference 2.1.
d) Sinusoidal vibration in any one axis may immediately be performed following random vibration in that same axis providing no change has been made in the setup.

5.4.1.2 Cleanliness of the tank shall be re-verified immediately following dynamics testing in accordance with the requirements of ARP-598 and Paragraph 4.3.5.3 of Reference 2.1.

5.4.1.3 The tank shall be subjected to a leakage test at MEOP to verify conformance with requirements. Allowable external leakage including tank joints shall not exceed 1 X 10^{-7} scc/sec when pressurized with 10% helium and 90% nitrogen at MEOP.

5.4.2 Procedures

(Reference 2.4, All Paragraphs)
(Reference 2.2, Paragraph 5.2)

5.4.2.1 The tank was subjected to the test requirements specified in Paragraph 5.4.1. The vibration testing was performed at and by Wyle Laboratories, El Segundo, California. The cleanliness verification was performed at and by NTS, Los Angeles, California. The helium leak test was performed at and by Lincoln Composites.

NOTE: A comprehensive report detailing the vibration testing is presented in Appendix 3 of this document. The following paragraphs present a brief description of the tests.

5.4.2.2 A dynamics fixture was installed on head of the electrodynamics vibration exciter. The test fixture was designed to simulate spacecraft installation; i.e., the port boss was rigidly restrained from motion in all directions, the blank boss was allowed to rotate and move in the longitudinal direction but was restrained from any motion in the radial or lateral directions. The tank was mounted to the dynamics fixture.

5.4.2.3 A dynamics fixture evaluation was performed in the longitudinal axis and in one lateral axis at -12 dB of the test levels. The tank was unpressurized during the dynamics test fixture evaluations.

5.4.2.4 The tank was pressurized to 4000 psig with helium gas and subjected to the following vibration in both the longitudinal axis and one lateral axis:

a) Low-level sinusoidal resonance search from 20 to 2000 Hz at 0.5 g with a sweep rate of 2 octaves per minute.
b) Sinusoidal vibration from 5 to 100 Hz at a sweep rate of 2 octaves per minute.
c) Random vibration from 20 to 2000 Hz at 4.6 gRMS for 2 minutes after equalization at -12, -9, -6, and -3 dB.
d) Low-level sinusoidal resonance search from 20 to 2000 Hz at 0.5 g with a sweep rate of 2 octaves per minute.

5.4.2.5 At the completion of each axis of vibration, the tank was depressurized for the axis change. The tank was visually examined after each axis for evidence of damage.

5.4.2.6 Upon completion of vibration testing the tank was returned to NTS for cleanliness verification.

5.4.2.7 The tank was returned to Lincoln Composites. The tank was subjected to an external helium leakage test. The tank was placed in a vacuum chamber which was evacuated and valved into a helium mass spectrometer. The tank was pressurized to 400 (±20) psig with helium gas and then to 4050 (±50) psig with nitrogen gas. The leak detector was monitored for indications of helium leakage for a period of 15 minutes. Procedural requirements state that leakage cannot exceed 1 X 10^{-7} scc/sec.

5.4.3 Results

5.4.3.1 The tank complied in all aspects to the requirements of the dynamics test.

5.4.3.2 The tank exhibited no visible evidence of damage as a result of the sinusoidal or random vibration.

5.4.3.3 Cleanliness verification results are presented in Paragraph 5.3 of this document.

5.4.3.4 The tank did not leak in excess of the specification requirements. Actual leakage rate was 1.2 X 10^{-9} scc/sec.

5.4.3.5 The test results obtained during the performance of the vibration testing are presented in Appendix 3 of this document. Test results obtained during cleanliness verification and helium leakage testing are presented in Appendix 2 of this document.

5.5 Burst Test

5.5.1 Requirements
(Reference 2.1, Paragraph 4.3.6.3)

5.5.1.1 The tank shall be stabilized at room temperature and then hydrostatically pressurized to rupture at a uniform rate not to exceed 125 psi per second.

5.5.1.2 The pressure required to rupture the tank shall be recorded.

5.5.1.3 The tank shall achieve design burst pressure (6000 psig) without rupture or leakage.

5.5.2 Procedures
(Reference 2.2, Paragraph 5.5)

5.5.2.1 The tank was subjected to the test requirements specified in Paragraph 5.5.1. This test was performed at and by Lincoln Composites.

5.5.2.2 The tank was filled with deionized water and connected to a burst pressure test system. The test system was energized and the tank was pressurized at an approximate linear rate, 75 to 125 psi per second, from 0 psig to rupture with a maximum 5 second hold at 4000 psig.

5.5.2.3 Test requirements are that the tank exhibit a rupture pressure in excess of 6000 psig at ambient temperature.

5.5.3 Results

5.5.3.1 The tank complied in all aspects to the specification requirements in the ability to exceed the 6000 psig minimum burst pressure.

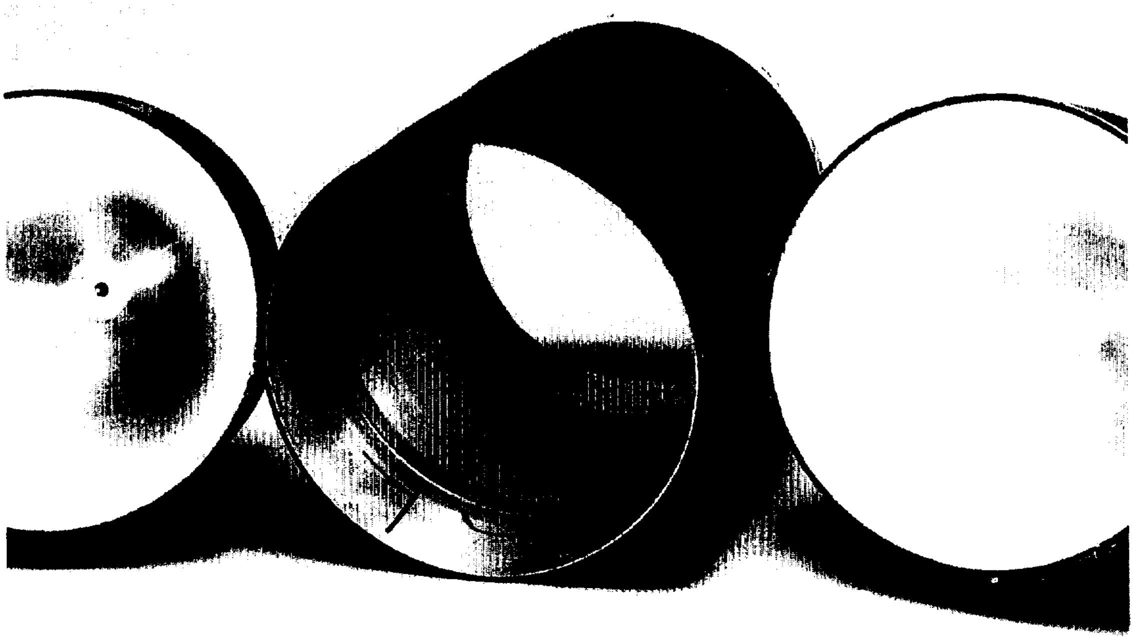
The tank exhibited leakage at 6500 psig (1.625 times the MEOP pressure of 4000 psig). At 7010 psig the leakage exceeded the capabilities of the test system to sustain pressurization. The test was aborted. Leakage origin was not determined.

5.5.3.2 Radiography of the tank did not definitively locate the source of failure. The domes of the tank were removed at the midway points between the tangents and the girth welds. Dissection revealed a crack in the root of the port end girth weld between 270° and 315° that was approximately 3 inches in length (the weld start-stop being 0°).

5.5.3.2 Photograph 1 presents the results of the dissection of the burst pressure test tank.

5.5.3.3 Pressure traces and data obtained during the performance of the burst pressure test is presented in Appendix 2 of this document.

PHOTOGRAPH 1
BURST TEST RESULTS



PRESSURANT TANK QUALIFICATION REPORT

XENON 65 L

Lincoln Composites
19410-53000-2

ATTACHMENT (4)

Report Number: 19410-53000-2
Date: 13 June 2000
Revision: NC

QUALIFICATION TEST REPORT

For

4000 ci XENON TANK

Space Systems/LORAL Part Number E137830-02
Lincoln Composites Part Number 220142-1
Serial Number 003

Per

Space Systems/LORAL
Performance Specification E172856
Revision 0

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REVISION PAGE

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1.0 INTRODUCTION

1.1 The purpose of this test report is to present the test requirements for, test procedures used, and test results obtained during the performance of a Qualification Test Program conducted on one (1) filament-wound, 4000 cubic inch Xenon Tank Assembly, Lincoln Composites Part Number 220142-1, Serial Number 003.

1.2 The purpose of the test program, performed on a tank assembly representative of flight (deliverable) hardware, was to qualify the tank assemblies for their intended use in systems for which they were designed.

1.3 The Qualification Test Program was conducted to demonstrate compliance with the requirements of Space Systems/LORAL Performance Specification Number E172856, Revision 0 (Reference 2.1). Tests were conducted in accordance with Lincoln Composites Quality Control Procedure Number QCP-06-742 (Reference 2.2) and Wyle Laboratories Procedure Number 5081 (Reference 2.4). Tests were performed at Lincoln Composites in Lincoln, Nebraska and Wyle Laboratories, El Segundo, California.

1.4 The Qualification Test Program, shown in the Table 1 Qualification Test Matrix, is summarized in Paragraph 3.0; detailed test requirements, test procedures and test results are presented in Paragraph 5.0 and attachments to this document.

TABLE 1
QUALIFICATION TEST MATRIX

Test Title	Sequence Number	Report Number (1)	Ref. 2.1 Paragraph (2)	Ref. 2.2 Paragraph (3)	Ref. 2.3 Paragraph (4)
Acceptance Test	1	5.1	4.3.4.1	5.1	- - -
Pressure Cycle Helium Leakage	2	5.2	4.3.6.1	5.2	- - -
Precision Cleaning	3	5.3	4.3.5.3	5.3	- - -
Dynamics Helium Leakage	4	5.4	4.3.6.2	5.4	All
Burst	5	5.5	4.3.6.3	5.5	- - -

(1) This document, Report Number 19410-53000-2
(2) Space Systems/LORAL Performance Specification E172856
(3) Lincoln Composites Quality Control Procedure QCP-06-742
(4) Wyle Laboratories Dynamics Procedure 5081

2.0 REFERENCE DOCUMENTS

2.1 Space Systems/LORAL Performance Specification Document Number E172856, Revision 0 titled: Xenon Tank, Performance Specification

2.2 Lincoln Composites Quality Control Procedure Number QCP-06-742, Revision A, titled: Qualification Test Procedure, Lincoln Composites Part Number 220142-1

2.3 Lincoln Composites Quality Control Procedure Number QCP-06-741, Revision A, titled: Acceptance Test Procedure, Lincoln Composites Part Number 220142-1

2.4 Wyle Laboratories Test Procedure Number 5081, Revision A, titled: Qualification Sinusoidal and Random Vibration of One Each Xenon and Helium Storage Tanks, Part Numbers 220142-1 and 220145-1

2.5 National Technical Systems Precision Cleaning Document Number 3898, Revision N/C, titled: Cleaning, Inspection and Sealing of Tank Assemblies for Space Systems Loral

3.0 SUMMARY

3.1 One (1) filament-wound Xenon Tank assembly, hereafter identified as tank, was submitted for testing in the Qualification Test Program. The tank was representative of production units and was identified as Lincoln Composites Part Number 220142-1, Serial Number 003. The tank was subjected to testing as summarized in Paragraphs 3.1.1 through 3.1.5.

3.1.1 **Acceptance Testing** - The tank was subjected to acceptance test procedures in accordance with QCP-06-741 (Reference 2.3) as required by Paragraph 5.1 of QCP-06-743 (Reference 2.2). The acceptance test procedures consisted of proof pressure-volume testing, helium leakage testing, and dimensional inspection. After completion of the acceptance testing, the tank was subjected to pressure cycle testing.

3.1.2 **Pressure Cycle Test** - The tank was subjected to pressure cycle testing in accordance with Paragraph 5.2 of QCP-06-742 (Reference 2.2). The pressure cycle testing was to consist of 4 hydrostatic cycles from 0 to 3375 psig, 8 hydrostatic cycles from 0 to 2970 psig, 40 hydrostatic cycles from 0 to 2700 psig, 3307 hydrostatic cycles from 2100 to 2700 psig, and 3307 hydrostatic cycles from 2100 to 2400 psig. Due to leakage of the test system during the 2100 to 2700 psig diurnal cycles, an engineering decision was made to expose the tank to an additional 800 each 2100 to 2700 psig cycles to compensate for that leakage. After completion of the pressure cycle testing, the tank was helium leak tested at 2700 psig using 10% helium and 90% nitrogen mixture, and was then subjected to precision cleaning.

3.1.3 **Precision Cleaning** - The tank was precision cleaned in accordance with Paragraph 5.3 of QCP-06-742 (Reference 2.2) and CPP3898 (Reference 2.5) by National Technical Systems (NTS), Los Angeles, California. After precision cleaning, the tank was forwarded to Wyle Laboratories for dynamics testing.

3.1.4 **Dynamics Testing** - The tank was subjected to sinusoidal and random vibration testing in accordance with Wyle Laboratories Procedure Number 5081 (Reference 2.4) as required by Paragraph 5.4 of QCP-06-742 (Reference 2.2). The dynamics testing consisted of sinusoidal and random vibration in the longitudinal and one radial direction while filled with 249 pounds of PF50/60 fluid and pressurized to 2700 psig with helium gas. The post-test cleanliness verification check was not performed. The fluid used during the vibration testing did not meet the cleanliness requirements of Reference 2.1, thereby making cleanliness verification superfluous. The tank was returned to Lincoln Composites and subjected to helium leakage testing including an extra MEOP pressurization (to achieve a total of 40 MEOP pressure cycles). The tank was then subjected to burst pressure testing.

3.1.5 **Burst Pressure Testing** - The tank was subjected to burst-to-rupture testing in accordance with Paragraph 5.5 of QCP-06-742 (Reference 2.2). The burst-to-rupture test consisted of hydrostatically pressurizing the tank from 0 psig to catastrophic failure, with a maximum 5 second hold at 2700 psig. The tank ruptured at 5500 psig with failure originating in the membrane section of the tank between the port end tangent line and the first girth weld.

3.2 The tank complied in all aspects to the requirements of Space Systems/LORAL Performance Specification E172856 (Reference 2.1). Prior to the burst test, the tank exhibited no evidence of deterioration, detrimental structural deformation, leakage beyond specification requirements, or other damage as a result of the imposed testing.

3.3 Serial Number 003 incorporated a design iteration that was dictated by the qualification test failure of Part Number 220145-1, Serial Number 002 Omega helium tank. The Serial Number 002 helium tank exhibited water leakage after the completion of 67 hydrostatic pressure cycles (of the then required 72 cycles) at MEOP. Investigation of the Serial Number 002 helium tank indicated that the large grain size of the forged aluminum liner was the major contributing factor. The tank liner was redesigned as a three-piece unit using port and blank liner halves from previously qualified Tempo pressure vessel forgings. A cylindrical section, 8.25" in length, machined from an identical qualified Tempo forging, was welded between the port and blank liner halves to obtain the specification requirement 4000 cubic inch volume. In addition to the redesign of the tank liner, the Reference 2.1 specification requirement for qualification pressure cycling was reduced in scope. The cycle life requirements were: 8 cycles at 1.25 X MEOP, 8 cycles at 1.1 X MEOP, 72 cycles at MEOP, plus diurnal cycles. The cycle life requirements are now: 4 cycles at 1.25 X MEOP, 8 cycles at 1.1 X MEOP, 40 cycles at MEOP plus diurnal cycles.

3.4 The liner assembly for Part Number 220145-1, Serial Number 003 Omega helium tank exhibited at 0.044" weld mismatch at 270° in the port-liner-half-to-cylinder-section circumferential weld, versus the Lincoln Composites drawing requirement of 0.021". The successful completion of the qualification testing on Part Number 220145-1, Serial Number 003 Omega helium tank that had the weld mismatch of 0.044" demonstrated the capability of the tank to satisfactory comply with Reference 2.1 specification requirements. Acceptance limits of 0.044" maximum weld mismatch for flight tanks, as demonstrated by the Omega helium qualification tank, will be used as the new acceptance inspection criteria.

3.5 The test program was initiated in May of 2000 and was completed in June of 2000.

3.6 All data obtained during the performance of Acceptance Testing and Qualification Testing is presented in Paragraph 5.0 and attachments to this document.

4.0 TEST CONDITIONS AND TEST EQUIPMENT

4.1 Test Conditions

Unless otherwise specified herein, the standard test conditions during the Qualification Test Program were an atmospheric pressure of site ambient, a temperature of 55° to 90° F and uncontrolled relative humidity.

4.2 Test Equipment

All test equipment used in the performance of testing and inspections during the Qualification Test Program, as detailed in Reference 2.2 and 2.3, was calibrated in accordance with ISO 10012-1 requirements relative to measuring, inspection and test equipment. Equipment calibrations were verified as current prior to the performance of tests and inspections.

5.0 QUALIFICATION TEST PROGRAM

5.1 Acceptance Test Procedures

5.1.1 Requirements

(Reference 2.1, Paragraph 4.3.5)

5.1.1.1 Acceptance testing shall be performed in the sequence specified for the tank being employed in the qualification test program. The tank shall satisfactorily complete acceptance testing prior to being place in the qualification test program.

5.1.1.2 Each tank shall be subjected to an acceptance test consisting of:

a) Proof pressure/volume
b) Helium leakage
a) Dimensional inspection

5.1.2 Procedures

(Reference 2.2, All Paragraphs)

5.1.2.1 The tank was subjected to the test requirements specified in Paragraph 5.1.1. These tests, normal to production tanks, were performed at and by Lincoln Composites.

5.1.2.2 The tank was subjected to acceptance testing in accordance with Reference 2.3 (QCP-06-741) as required by Reference 2.2 (QCP-06-742) of this document:

a) Proof pressure testing to 3375 psig using deionized water per Paragraph 5.1 of QCP-06-741.
b) Volume measurements using water weight versus temperature to determine volumetric capacity (4000 cubic inches minimum volume) per Paragraph 5.1 of QCP-06-741.
c) External leakage testing using the vacuum chamber method while pressurized to 2700 psig with a 10% helium gas mixture (maximum leakage rate not to exceed 1 X 10^{-7} scc/sec) per Paragraph 7.1 of QCP-06-741.
d) Visual and dimensional inspection per Manufacturing & Inspection Record (M&IR 175077-1) processing.

NOTE: Precision cleaning is a requirement of normal acceptance testing before delivery of the tank to its final destination. For the qualification tank, the precision cleaning was deferred to immediately prior to dynamics testing in accordance with Table IV and Table V of SS/L E172856 (Reference 2.1).

5.1.3 Results

5.1.3.1 The tank complied in all aspects to the requirements of the test procedure.

5.1.3.2 Acceptance test results.

TABLE 2
ACCEPTANCE TEST RESLTS

Max. Proof Press (psig)	Volume @ 0 psig (cu. in.)	Max. Leakage (scc/sec)	Permanent Set (%)
3384	4030.0	1.8×10^{-8}	0.46

5.1.3.3 The test results and proof pressure traces obtained during the performance of the acceptance test procedures are presented in Appendix 1 of the document along with the recorded visual and dimensional data.

5.2 Pressure Cycle Test

5.2.1 Requirements

(Reference 2.1, Paragraph 4.3.6.1)

5.2.1.1 The tank shall be subjected to a negative pressure of 20 psid at ambient temperature.

5.2.1.2 The tank shall be subjected to hydrostatic pressure cycling at ambient temperature from ambient pressure to 1.25 times MEOP, 1.1 times MEOP, MEOP, and diurnal cycles using water. The number of cycles applied shall be sufficient to achieve a total of 4 each 1.25X MEOP cycles, 8 each 1.1X MEOP cycles, 40 each MEOP cycles, and 6614 diurnal cycles including all qualification pressurizations prior to burst testing.

5.2.1.3 The tank shall be subjected to a leakage test at MEOP to verify conformance with requirements. Allowable external leakage including tank joints shall not exceed 1×10^{-7} scc/sec when pressurized with 10% helium and 90% nitrogen at MEOP.

5.2.2 Procedures

(Reference 2.2, Paragraph 5.2)

5.2.2.1 The tank was subjected to the test requirements specified in Paragraph 5.2.1. This test was performed at and by Lincoln Composites.

5.2.2.2 The tank was installed in a pressure autoclave with the interior of the tank vented to atmospheric pressure. The autoclave was pressurized to 21.6 psig. The pressure was maintained for 5.5 minutes and then reduced to ambient.

5.2.2.3 The tank was removed from the autoclave and visually examined for deformation, distortion or other damage caused by the external pressures.

5.2.2.4 The tank was hydrostatically pressure cycled using deionized water. The pressures and sequence of application were as shown in Table 3.

5.2.2.5 The overall length differential growth effected by pressure was measured during one pressure cycle from 0 to 2700 to 0 psig. During the last cycle of pressure from 2700 to 0 psig, the effluent liquid from the tank was captured and weighed. The volume of the effluent water was calculated using water weight versus temperature times the compression factor of water at 2700 psig. The effluent volume was added to the 0 psig volume determined during acceptance testing to determine overall volume of the tank at 2700 psig.

5.2.2.6 The tank was visually examined for evidence of damage at the completion of the pressure cycles.

TABLE 3
PRESSURE CYCLE TEST PARAMETERS

Sequence	Number of Cycles (1)	Pressure Range (psig)
A	4	0 to 3375 to 0
B	8	0 to 2970 to 0
C	34	0 to 2700 to 0
D	3307 (2) + 800	2100 to 2700 to 2100
E	3307	2100 to 2400 to 2100
Tolerances:	+50/-0 psig at minimum and maximum pressures	
Ramp rate:	75 to 125 psi per second	
Hold time at peak:	5 seconds maximum pressure	

(1) Number of 2700 psig pressure cycles reduced from 40 to 34 to compensate for expected MEOP cycles to be applied during qualification program.

(2) An additional 800 each 2100-2700-2100 cycles were applied to compensate for low pressures experienced as a result of leakage within test system.

5.2.2.7 At the completion of pressure cycling, the tank was subjected to an external helium leakage test. The tank was placed in a vacuum chamber that was evacuated and valved into a helium mass spectrometer. The tank was pressurized to 270 (±10) psig with helium gas and then to 2750 (±50) psig with nitrogen gas. The leak detector was monitored for indications of helium leakage for a period of 15 minutes. Procedural requirements state that leakage cannot exceed 1 X 10^{-7} scc/sec.

5.2.3 Results

5.2.3.1 The tank complied in all aspects to the requirements of the pressure cycle test.

As a result of leakage in the hydrostatic pressure test system, reduced pressure cycles were applied to the tank during some portions of the 2100-2700-2100 psig diurnal cycles. In accordance with directions of Lincoln Composites program engineering and SSL engineering additional cycles were applied to the tank to compensate for these reduced pressure cycles. It was determined that an additional 800 each 2100-2700-2100 psig diurnal cycles were to be performed; this resulted in a total of 4107 cycles versus the specification requirement of 3307 cycles.

5.2.3.2 The tank exhibited no evidence of leakage or visual damage as a result of the cyclic pressurizations.

5.2.3.3 The overall length differential growth of the tank was 0.307 inches. The effluent volume of the tank, from 2700 psig to 0 psig, was 106.8 cubic inches. The total calculated volume of the tank at 2700 psig was 4136.8 cubic inches.

5.2.3.4 The tank did not leak in excess of the specification requirements. Actual measured leakage was 6.4×10^{-8} scc/sec.

5.2.3.5 Data obtained during the performance of the pressure cycle test is presented in Appendix 2 of this report.

5.3 Precision Cleaning

5.3.1 Requirements

(Reference 2.1, Paragraph 3.4.1.2 and 4.3.5.3)

5.3.1.1 Cleanliness of the tank shall be verified in accordance with the requirements of ARP-598 and shall meet the requirements of Paragraph 3.4.1.2 of Reference 2.1.

5.3.1.2 The interior surface of the tank shall be maintained in a cleaned condition during dynamics testing by means of an in-line filter attached to the inlet tube. The in-line filter shall not be removed until cleanliness verification after dynamics testing has been initiated.

5.3.2 Procedures

(Reference 2.2, Paragraph 5.3)

5.3.2.1 The tank was subjected to the cleaning requirements specified in Paragraph 5.3.1 prior to dynamics testing,. The cleaning was performed at and by NTS, Los Angeles, California.

5.3.2.2 The external surfaces of the tank were cleaned to remove dust, grease, oil and other soils.

5.3.2.3 The internal surfaces of the tank were pre-cleaned using isopropyl alcohol, Turco 4215, deionized water and gaseous nitrogen. After pre-cleaning operations were performed, the internal surfaces were precision cleaned in a Class 10,000 clean room using 0.5 micron filtered isopropyl alcohol. A 1000-milliliter sample of the effluent alcohol was then sampled for particulates.

5.3.2.4 The tank was dried in a vacuum oven at 140° F at a vacuum of 27 ±2 inches of Mercury for a minimum of 2 hours.

5.3.2.5 After removal from the drying oven, a 2-micron nominal in-line pleated mesh filter was installed on the inlet tube of the tank. The tank was then packaged in a 2-mil nylon film bag and then over-bagged with 6-mil polyethylene.

5.3.3 Results

5.3.3.1 The tank complied in all aspects to the requirements of the cleaning operations.

5.3.3.2 Cleaning particulate counts were:

TABLE 4
PRECISION CLEANING RESULTS

Size (microns)	Ref. 2.1, Para. 3.4.1.2 Requirements	Initial Clean Results (pre-vibr.)	Cleanliness Verification Results (post-vibr.)
	(per 100 ml)		
<5	No silting	None	Not performed. Fluid used during vibr. did not meet rqmt's of Table 4 thereby making cleanliness verification surperfluous.
5 to 10	600	410	
11 to 25	100	82	
26 to 50	25	13	
51 to 100	4	2	
>100	0	0	
NVR	<1.0 mg	0.5 mg	

5.3.3.3 The cleaning certifications and particulate count data sheets obtained during the performance of these operations are presented in Appendix 2 of this document.

5.4 Dynamics Testing

5.4.1 Requirements

(Reference 2.1, Paragraph 4.3.6.2)

5.4.1.1 The tank shall be subjected to dynamics testing while filled with a performance fluid and pressurized with helium to MEOP with the tank end bosses attached to a rigid fixture.

a) A vibration survey of the test fixture, with the tank mounted, shall be performed by swept sinusoid or low level random applied in the axial direction and one lateral direction
b) Random vibration shall be applied consecutively in the axial direction and one lateral direction at levels specified in Table VI of Reference 2.1.
c) Sinusoidal vibration shall be applied consecutively in the axial direction and one lateral direction at levels specified in Table VI of Reference 2.1.
d) Sinusoidal vibration in any one axis may immediately be performed following random vibration in that same axis providing no change has been made in the setup.

5.4.1.2 Cleanliness of the tank shall be re-verified immediately following dynamics testing in accordance with the requirements of ARP-598 and Paragraph 3.4.1.2 of Reference 2.1.

5.4.1.3 The tank shall be subjected to a leakage test at MEOP to verify conformance with requirements. Allowable external leakage including tank joints shall not exceed 1 X 10^{-7} scc/sec when pressurized with 10% helium and 90% nitrogen at MEOP.

5.4.2 Procedures

(Reference 2.3, All Paragraphs)
(Reference 2.2, Paragraphs 5.4.2.3 - 5.4.2.7)
(Reference 2.2, Paragraphs 5.4.2.8 - 5.4.2.10)

5.4.2.1 The tank was subjected to the test requirements specified in Paragraph 5.4.1. The vibration testing was performed at and by Wyle Laboratories, El Segundo, California. The helium leak test was performed at and by Lincoln Composites.

NOTE: A comprehensive report detailing the vibration testing is presented in Appendix 3 of this document. The following paragraphs present a brief description of the tests.

5.4.2.2 A dynamics test fixture was installed on the head of the electrodynamics vibration exciter. The test fixture was designed to simulate spacecraft installation; i.e., the port boss was rigidly restrained from motion in all directions, the blank boss was allowed to rotate about and move in the axial or longitudinal direction but was restrained from any motion in the radial or lateral directions. The tank was then mounted to the dynamics fixture.

5.4.2.3 A dynamics fixture evaluation was performed in the axial or longitudinal axis and in one lateral axis at -12 dB of the test levels. The tank was at ambient pressure (unpressurized) during the dynamics test fixture evaluations.

5.4.2.4 The tank was filled with 249 pounds (113 kilograms) of PF 50/60 performance fluid and pressurized to 2700 psig with helium gas. The tank was subjected to the following vibration in both the axial or longitudinal axis and one lateral axis.:

a) Low-level sinusoidal resonance search from 20 to 2000 Hz at 0.5 g with a sweep rate of 2 octaves per minute.
b) Sinusoidal vibration from 5 to 100 Hz at a sweep rate of 2 octaves per minute.
c) Random vibration from 20 to 2000 Hz at an overall level of 4.6 gRMS for 2 minutes after equalization at -12, -9, -6, and -3 dB.
d) Low-level sinusoidal resonance search from 20 to 2000 Hz at 0.5 g with a sweep rate of 2 octaves per minute.

5.4.2.5 At the completion of each axis of vibration, the tank was depressurized for axis change. The tank was visually examined after each axis for evidence of damage.

5.4.2.6 The tank was returned to Lincoln Composites. The tank was subjected to an external helium leakage test. The tank was placed in a vacuum chamber that was evacuated and valved into a helium mass spectrometer. The tank was pressurized to 270 (±10) psig with helium gas and then to 2750 (±50) psig with nitrogen gas. The leak detector was monitored for indications of helium leakage for a period of 15 minutes. Procedural requirements state that leakage cannot exceed 1 X 10^{-7} scc/sec.

5.4.3 Results

5.4.3.1 The tank complied in all aspects to the requirements of the dynamics test.

5.4.3.2 The tank exhibited no visible evidence of damage as a result of the sinusoidal or random vibration.

5.4.3.3 Cleanliness verification of the tank was not performed. The PF50/60 fluid used during vibration testing did not meet the requirements of Table 4 of this document. The use of "unclean" performance fluid contaminated the tank thereby making a cleanliness verification check superfluous.

5.4.3.4 The tank did not leak in excess of the specification requirements. Actual leakage rate was 1.0 X 10^{-9} scc/sec. Prior to the leakage test, an additional MEOP cycle of 0 to 2700 to 0 psig was pneumatically performed. The purpose of the additional cycle was to comply with the requirements of 40 MEOP cycles prior to burst test.

5.4.3.5 The test results obtained during the performance of the vibration testing are presented in Appendix 3 of this document. Test results obtained during the helium leakage testing are presented in Appendix 2 of this document.

5.5 Burst Test

5.5.1 Requirements
(Reference 2.1, Paragraph 4.3.6.3)

5.5.1.1 The tank shall be stabilized at ambient temperature and then hydrostatically pressurized to rupture at a uniform rate not to exceed 125 psi per second.

5.5.1.2 The pressure required to rupture the tank shall be recorded.

5.5.1.3 The tank shall achieve design burst pressure (4050 psig) without rupture or leakage.

5.5.2 Procedures
(Reference 2.2, Paragraph 5.5)

5.5.2.1 The tank was subjected to the test requirements specified in Paragraph 5.5.1. This test was performed at and by Lincoln Composites.

5.5.2.2 The tank was filled with deionized water and connected to a burst pressure test system. The burst pressure test system was energized and the tank was pressurized at an approximate linear ramp rate, 75 to 125 psi per second, from 0 psig to rupture of the tank with a maximum 5 second hold at 2700 psig.

5.5.2.3 Test requirements are that the tank exhibit a rupture pressure in excess of 4050 psig at ambient temperature.

5.5.3 Results

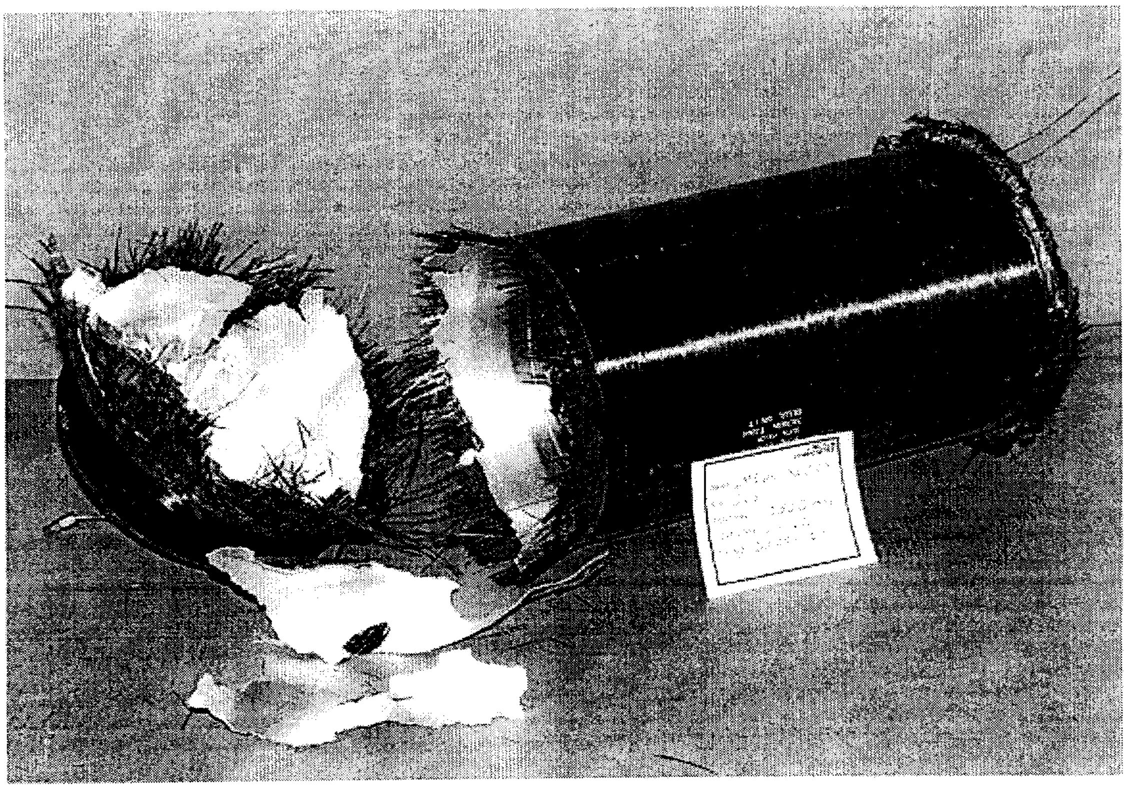
5.5.3.1 The tank complied in all aspects to the specification requirements.

The tank ruptured at 5500 psig (2.04 times the MEOP pressure of 2700 psig). Failure originated in the membrane area of the tank, between the port tangent line and the first girth weld.

5.5.3.2 Photograph 1 presents the results of the burst pressure test.

5.5.3.3 Pressure traces obtained during the performance of the burst pressure testing are presented in Appendix 2 of this document.

PHTOGRAPH 1
BURST TEST RESULTS



JUSTIFICATION OF EXEMPTION PROPOSAL

107.105(d)(1) Relevant shipping and incident experience.

SS/L has had experience with shipping spacecraft in a spacecraft shipping container, such as these, since 1966. It is estimated that there will be at least ten spacecraft shipments per year (for either testing purposes or to be launched into space). To date there have been no shipping or transporting incidents during this 36 year period.

107.105(d)(2) Statement of increased risk to safety or property.
Not applicable. There is no increased risk of safety or property as a result of granting this exemption.

107.105(d)(3)(i)
As described in section 107.105(c)(3) of this document, each spacecraft pressurant tank is designed to meet MIL-STD-1522A requirements for pressure vessels. Each tank requires Qualification and Acceptance Testing with reports as shown in Attachments (3) and (4). All the information provided within the attachments indicates the pressurant tank designs met all the performance requirements criteria.

107.105(d)(3)(ii)
It is SS/L's intent to ensure that a more stringent level of safety exists with the spacecraft propulsion tanks design, the propulsion tanks shipping and storage pressures and the spacecraft packaging and shipping configuration. All the information provided here is consistent with the approach of an existing SS/L DOT exemption DOT-E 11103 (renewal expires December 31, 2002) and DOT-E 12341 (renewal expires April 30, 2004).

SUMMARY:
All the qualification tanks have successfully demonstrated the leak-before-burst design requirement. As indicated in Tables 1-1 and 1-2, the pressurant tank transportation safety factors for each pressurant tank are greater than 14:1. In the unlikely event of a tank rupture, because of the LBB design, the tank would not shatter and cause shrapnel, thus allowing the inert gas to leak out until ambient pressure is achieved. The spacecraft structures along with the shipping containers environmental conditioning capabilities would contain the flow of gas to the environment. There are no inherent risk or hazard to the public, property or the environment due to tank failure.

Alan Eft

Alan Eft
Program Safety Manager
Space Systems/Loral

October 2, 2002

TO: Sandra Cureton

Fax: (202) 366-3308

Subj: Signature page for Exemption request, my letter DX6200-AWE-2002-016, dated August 30, 2002

Attached is a copy of the signature page for the above Exemption request.

The original page will be forwarded.

Also, a vessel qualification report, that was not available at the time of submission, will also be forwarded.

Thank you for your attention on this matter. I am sorry that I did not include the signature page, thus requiring you to contact me.

Alan Eft

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